Managing Commercial Tree Species for Timber Production and Carbon Sequestration: Management Guidelines and Financial Returns

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by

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Abstract

A carbon credit market is developing in the United States. Information is needed by buyers and sellers of carbon credits so that the market functions equitably and efficiently. Analyses have been conducted to determine the optimal forest management regime to employ for each of the major commercial tree species so that profitability of timber production only or the combination of timber production and carbon sequestration is maximized. Because the potential of a forest ecosystem to sequester carbon depends on the tree species, site quality and management regimes utilized, analyses have determined how to optimize carbon sequestration by determining how to optimally manage each species, given a range of site qualities, discount rates, prices of carbon credits and other economic variables. The effects of a carbon credit market on the method and profitability of forest management, the cost of sequestering carbon, the amount of carbon that can be sequestered, and the amount of timber products produced has been determined.

DISCLAIMER

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INTRODUCTION

Average global temperatures have increased by 0.6 ± 0.2°C over the last 100 years, with projected increases of 1.4 to 5.8°C by the end of the twenty-first century. Increases in greenhouse gas concentrations are projected to cause severe fluctuations in global weather patterns and a rise in the mean sea level of 45 cm (IPCC 2001).

The greenhouse gasses of concern include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), with CO_2 being of principal concern. With the increased amounts of CO_2 emissions, the international community began negotiations to mitigate the trends in increasing global temperatures. These negotiations led to the 1997 Kyoto Protocol, a legally binding document that focused on reducing greenhouse emissions by 7 percent by 2012 as compared to 1990 levels (Fletcher 2000). Although the United States did not ratify the protocols, efforts are being made to meet its reduction goals.

The United States is the largest contributor of greenhouse gasses worldwide. Therefore, drastic reductions in its use of fossil fuels would be required to mitigate the effects of global warming. Meeting the reduction caps proposed by the Kyoto Protocol would lead to higher energy costs, and decreases in U.S. productivity, the economy, and standard of living (U.S. Senate Committee on Energy and Natural Resources 2001). Because of this, alternative methods for the reduction of greenhouse gasses must be considered.

One alternative, known as carbon sequestration, is to use forests as carbon sinks. Forests cover 65% of the earth's land mass, contain 90% of the total terrestrial vegetation carbon, 80% of the total terrestrial soil carbon, and assimilate 67% of the total CO_2 removed from the atmosphere by all terrestrial ecosystems (Gower 2003). Biotic vegetation acts as carbon reservoirs by removing CO_2 from the atmosphere and fixing it into plant tissues, dead organic matter, and soils (IPCC 2001). Worldwide, there are 345 million hectares of land available for afforestation, reforestation, and silvicultural management activities (Brown et al. 1996). Forests on these lands would have the ability to sequester approximately 37.6 gigatonnes of carbon over the next 50 years (Brown et al. 1996).

Previous studies have been conducted to determine financially optimal forest rotation schedules when both timber and carbon are considered (Bates 2002, Cheng 2003, Huang 1999). However, these studies encompassed only five species (Northern red oak, cherrybark oak, green ash, cottonwood, and loblolly pine) in the eastern continental United States. Huang and Kronrad (2002) reported financially optimal thinning and harvest schedules for loblolly pine on non-industrial private forestland in East Texas. Their results, which were for timber only, showed that as ARR and site index increase rotation length decreases. Huang (1999), Bates (2002), and Cheng (2003) included carbon data in their analysis, and found that including carbon credits improved the profitability of growing timber.

The need to offset increasing global carbon emissions is growing. Therefore, a study to determine optimal forest rotation schedules for even-aged, single species stands, which maximize returns from both timber and carbon, was critical. This study examined the profitability of managing multiple species across 10 regions of the United States. All of the included species are economically important for either pulpwood or sawtimber production.

METHODS

This study investigated the profitability of afforestation and reforestation of twenty-four financially important tree species across 10 regions of the United States for timber production only and for a combination of timber production and carbon sequestration.

Data Collection

Financially Optimal Harvest Schedule

The harvest schedule that maximizes financial return is dependent on the following biological and economic parameters:

1. Biological

- Species
- Silvicultural characteristics
- Site index
- Diameter classes
- Biological inputs and associated timing (fire, site preparation, thinning, burning)
- Thinning intensities
- Residual growing stock levels

2. Economic

- Landowner's ARR
- Real price and cost increases
- Costs (site preparation, seedlings, planting, burning, marking and administering)

- Revenues (stumpage prices, carbon credits)

The Forest Management Optimizer (FORMOP), an iterative program similar to those developed by Huang (1999) and Bates (2002) was used in this study. This program was developed to simulate stand growth and yield with and without thinnings and conduct economic analyses. FORMOP is an economic program that determines the profitability of forest rotations as obtained from the program it is integrated with. FORMOP was integrated with the Forest Vegetation Simulator (FVS) (USDA Forest Service 1973) such that FVS will be used to simulate stand growth from establishment to final harvest, including thinnings. FVS is a growth and yield program developed by the USDA Forest Service, and is based upon a body of scientific knowledge developed from decades of natural resources research. Both economic and biological data were input into the FORMOP program, FORMOP then calculated the total tons of carbon stored, soil expectation value (SEV), and net present worth (NPW) of every possible thinning and harvesting regime generated by FVS. It then ranked all iterations to determine financially optimal management regimes and calculated the quantity of carbon stored.

One ton of carbon will be assumed to equal one carbon credit. The Chicago Climate Exchange is a voluntary and legally binding program for reducing and trading greenhouse gas emissions in North America. Current carbon credit prices per metric ton were $4.50 as of June 23, 2006 (Chicago Climate Exchange, http://www.chicagoclimateexchange.com/#. June 26, 2006). However, the market is relatively new and prices can be expected to change as the market develops. Therefore, carbon prices per ton will be estimated at values commonly discussed in the literature. The values used in this study were $10, $37, and $50 per ton. A $0 per ton value will be used to establish a scenario with no carbon credit market. The $37 value was requested by the U.S. Department of Energy as a value to be used in association with all species.

Economic data were gathered based upon current market prices, with future costs and revenues predicted through inflation and real price increases. Alternative rates of return (ARR) represent an individual's opportunity cost of capital and are determined by an individual's best alternative use for his or her money. Since ARRs differ significantly among individuals and can be difficult to determine, a range of 6 real ARRs (2.5, 5, 7.5, 10, 12.5 and 15 percent) were used for the study. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation.

Economic Analysis

Economic analysis were used to determine the maximum soil expectation values (SEV) associated with timber production and carbon storage of each even-aged single species forest stand. This was done by first determining the net present worth (NPW) associated with timber production and carbon storage for various harvest schedules. The computer model FORMOP was used to determine the NPW for carbon and timber separately and to calculate an NPW for carbon and timber together. Net present worth is the sum of the present value of revenues minus the sum of the present value of costs.

The formula for NPW is:

$$NPW = \sum_{y=0}^{n} \left[\frac{R_y}{(1+r)^y} - \frac{C_y}{(1+r)^y} \right]$$

where,

R_y = revenue in year y

C_y = cost in year y

n = number of years in the rotation

r = real alternative rate of return

y = year at which the revenue or cost occurs

The NPW's for both carbon and timber were used to calculate soil expectation values (SEV). Because starting from bare land SEV represents the discounted NPW of all future expected cash flows.

The SEV formula is:

$$SEV = NPW\left\{\left[\frac{1}{(1+r)^n - 1}\right] + 1\right\}$$

where,

n = number of years in the rotation

r = real alternative rate of return

The SEV's will then be compared to determine the optimal harvest schedule for carbon storage and timber production.

Report Format

Biological data for each species are presented at the beginning of each section in the form of a literature review, and within the assumptions pages for each species by region. For example white oak is economically important in both the Central States and Southern region. Because of this the white oak data is divided by region and sorted alphabetically. The layout for the data is: Literature review, Central States Assumptions, Tables, Results; Southern Assumptions, Tables, Results.

Description of Presented Tables

Examples in this section use data from loblolly pine in the Southern region.

Managing for Timber Production only:

Table 1 presents the number of **net tons of carbon stored** in the forest during one rotation. Only carbon stored in long-term forest products are counted. If a landowner's alternative rate of return is 5% and his site index is 70, this forest will store 40.28 tons per acre. But if a landowner's alternative rate of return is 12.5% and his site index is 70, only 33.92 tons of carbon will be stored during one rotation. Less tons are stored because the forest rotation is shorter.

Table 5 presents the **financially optimal thinning and final harvest schedules,** which show how and when to thin and harvest the forest in order to earn the most money possible. If a landowner's alternative rate of return is 5% and his site index is 70, the landowner will earn the most money by thinning the stand first at age 23 and thinning it again at age 29. Thirty percent of the trees should be removed at each thinning. The stand should be clearcut when it is 48 years of age. Tables 5 and 9 show that forestry is unprofitable for a landowner who has an alternative rate of return of 12.5% and a site index of 70. But Table 3 tells when to thin and harvest the stand in order to minimize losses. In this case the stand should be thinned first at age 23, thinned again at age 28, and clearcut at age 43.

Table 9 presents the **net present worth (NPW)**, or profit, that can be earned by managing an acre of loblolly pine plantation in the optimal manner. To use this table a landowner must know his forest's site index and his alternative rate of return. Site index is a measure of the soil's productivity. Site index, using "base age 25", tells how tall the trees will be when they are 25 years of age. A site index 70 (base age 25) means that at age 25 the trees will be 70 feet tall. Foresters are familiar with site index, and most forestland has been measured. A landowner can find out what his land's site index is by contacting his state forester or the local office of the Natural Resource Conservation Service. Alternative rate of return is determined by a landowner asking himself, "If I had some extra money that I could invest, how much could I earn on that investment?" If a landowner could earn 5% per year in a long-term investment and his land has a site index of 70, then data in Table 9 indicates that this landowner will earn 5% on his loblolly pine plantation investment plus an additional $336.79 per acre during one rotation.

Table 13 presents the **soil expectation value (SEV)**,which shows the discounted NPW of an infinite series of rotations, or land value. To use this table a landowner must know his forest's site index and his alternative rate of return. If a landowner could earn 5% per year in a long-term investment and his land has a site index of 70, then data in Table 13 indicates that this landowner will earn 5% on his loblolly pine plantation investment plus an additional $370.74 per acre.

Table 17 presents the **volume removed**, which shows the total volume harvested by following the optimal rotation schedule. Following the financially optimal thinning and harvest schedule presented in Table 5 if a landowner's alternative rate of return is 5% and his site index is 70, the landowner will harvest a total of 1,876.15 cubic foot of pulpwood and 18.80 thousand board feet (MBF) of sawtimber per acre during one rotation.

<u>Managing for the Combination of Timber Production and Carbon Credits:</u>

Table 2 presents the number of **net tons of carbon stored** in the forest during one rotation given the existence of a carbon credit market. As shown in Table 6, as the price of carbon credits increases the rotation length tends to increase. The longer the rotation the greater the amount of carbon that will be stored in the forest and, eventually, in long-lived wood products. Assuming there is no market for carbon credits (carbon value= $0/ton), landowners who have an alternative rate of return is 10.5% and a site index of 70 will store 63 tons of carbon in long-lived wood products. But if carbon credits can be sold for $10 per ton then landowners will earn the most money by storing 70 tons during one rotation. If a landowner's alternative rate of return is 8.0% and his site index is 70, 79 tons of carbon will be stored during one rotation when carbon credits can be sold for $10 per ton.

Table 6 presents the **financially optimal thinning and final harvest schedules,** which show how and when to thin and harvest the forest in order to earn the most money possible; the amounts shown in Table 5. If a landowner's alternative rate of return is 5%, his site index is 70 and there is no market for carbon credits (carbon value= $0/ton), the landowner will earn the most money possible by thinning the forest first at age 23 and thinning it again at age 29. Thirty percent of the trees should be removed at each thinning. The stand should be clearcut when it is 48 years of age. If carbon credits can be sold for $10 per ton then the stand should be thinned at age 23 and 29, and 30% of the stand should be removed at each thinning. The forest should be clearcut at age 48.

Table 10 present the **net present worth (NPW)** that a landowner will earn if a market exists for carbon credits and a landowner sells his forest products and sells his credits as they are stored in the forest. For example, if there is no market for carbon credits (carbon value= $0/ton) and a landowner's alternative rate of return is 5% and his site index is 70, then he will earn 5% on his investment plus $336.79 per acre from selling his forest products only. But if a market exists for carbon credits and they can be sold for $10 per ton, then this landowner will earn 5% plus $529.66 per acre by selling carbon credits and timber products.

Table 14 present the **soil expectation value (SEV)** that a landowner can expect if a market exists for carbon credits and a landowner sells his forest products and sells his credits as they are stored in the forest. For example, if there is no market for carbon credits (carbon value= $0/ton) and a landowner's alternative rate of return is 5% and his site index is 70, then he will earn 5% on his investment plus $370.74 per acre from selling his forest products only. But if a market exists for carbon credits and they can be sold for $10 per ton, then this landowner will earn 5% plus $583.05 per acre by selling carbon credits and timber products.

Table 18 presents the **volume removed**, which shows the total volume harvested by following the optimal rotation schedule. Following the financially optimal thinning and harvest schedule presented in Table 6 if a landowner's alternative rate of return is 5%

and his site index is 70, the landowner will harvest a total of 1,876.15 cubic foot of pulpwood and 18.80 thousand board feet (MBF) of sawtimber per acre during one rotation.

Table 21 presents the **change in rotation length**, which shows the increase caused by increasing values for carbon credits . Following the previous examples if a landowner's alternative rate of return is 5% and his site index is 70, there is no change in rotation length between the base carbon price of $0 and C=$10 per ton. However when carbon prices equal $37 per ton rotation length increases by 2% over the base carbon price.

Table 22 presents the **change in SEV**, which shows the increase caused by increasing values for carbon credits . Following the previous examples if a landowner's alternative rate of return is 5% and his site index is 70, there is there is a gain in SEV of 57% between the base carbon price of $0 and C=$10 per ton. When carbon prices equal $37 per ton SEV gains 213% over the base carbon price. The gain in SEV is only calculated if the base SEV (SEVtp) is positive.

American basswood - *Tilia americana* L.

Biological information

American basswood is a large, rapid growing tree, which grows best in the central part of its range on deep, moist soils, and vigorously develops from both sprouts and seed (USDA Forest Service. Silvics manual. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/tilia/americana.htm. July 21, 2006).

American basswood ranges from southwestern New Brunswick and New England; south to Nebraska, Kansas and northeastern Oklahoma; east to Northeastern Arkansas, Tennessee, North Carolina; and northeast to New Jersey (USDA Forest Service. Silvics manual. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/tilia/americana.htm. July 21, 2006). (Fig. 1).

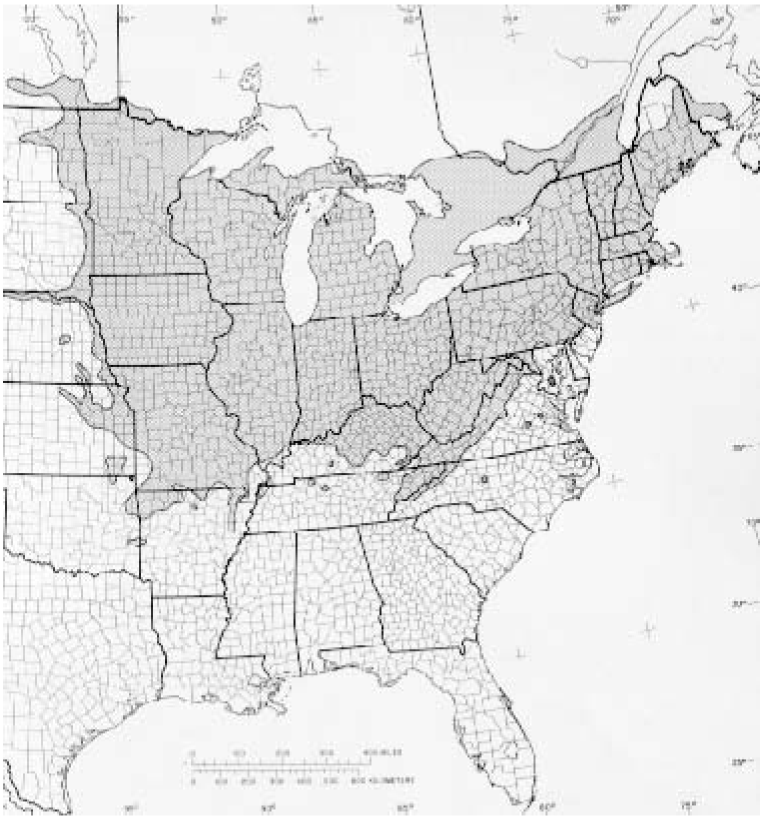

Fig. 1. The native range of American basswood. (USDA Forest Service. Silvics manual. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/tilia/americana.htm. July 21, 2006).

A height of 75 to 130 ft. with a d.b.h. of 36 to 48 in. is very common for American basswood. Under favorable conditions, it can even attain a height of 140 ft. with a maximum diameter of 54 in. (USDA Forest Service. Silvics manual. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/tilia/americana.htm. July 21, 2006).

Diameter growth for basswood averaged 0.11 in. per year in three unmanaged site index 70 (base age 50) stands in northeastern Wisconsin. The growth rate was much higher on the same site under managed conditions. Annual growth rate for crop tree release was 0.18 in; for a 90 ft^2 and 75 ft^2/acre residual sawtimber selection cut, it was 0.15 and 0.19 in.; and for a group selection cut, the figure was 0.12 in. (USDA Forest Service. Silvics manual. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/tilia/americana.htm. July 21, 2006).

The soft, light wood of American basswood makes it valuable as a timber tree and for many wood products, such as basket and mats. Basswood is also well-known as a honey tree. It is also commonly planted as an urban shade tree throughout the Eastern United States (USDA Forest Service. Silvics manual. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/tilia/americana.htm. July 21, 2006).

Species American basswood Region South

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 9-in. inside bark top diameter for trees with a minimum of 12 inches in diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 11-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 20 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 25, 30 and 35% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.245225694 and 0.434027778, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Clark and Schroeder (1986) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Yp = 0.15030(D^2H)^{0.93298}$$

$$Ys = 0.15789(D^2)^{0.92271}(H)^{0.93298}$$

where:

Yp = dry-weight (lbs.) of stemwood and bark of trees < 11.0 in. d.b.h

Ys = dry-weight (lbs.) of stemwood and bark of trees ≥ 11.0 in d.b.h

D = diameter at breast height (in.)

H = total height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 1.6% and 1.24% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0 .47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $128.25/mbf (Scribner) (Timber Mart South, Inc. 2000-2005) and pulpwood price was assumed to be $16.44/cord (Timber Mart South, Inc. 2000-2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of American basswood plantations in the South.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$60.00	Only once	Year 0	
Seedlings[b] (436 seedlings/ac)	$152.60	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).

[b]Data from Hans M. Williams, personal communication, Stephen F. Austin State University, December 19, 2006.

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Table 1. Total tons of carbon sequestered per acre for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	19.00	19.00	19.00	19.00	19.00	19.00
80	26.96	26.96	25.01	23.58	22.74	22.13
90	30.38	30.38	30.38	26.98	25.64	25.15

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	19.00	19.00	19.00	19.00	19.00	19.00
80	26.96	26.96	26.96	25.01	23.58	22.41
90	30.38	30.99	30.99	30.99	25.78	25.78

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	23.06	23.06	23.06	23.06	23.06	23.06
80	26.96	26.96	26.96	26.96	26.96	26.96
90	33.40	33.31	33.31	33.31	32.90	33.09

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	23.06	23.06	23.06	23.06	23.06	23.06
80	26.96	26.96	27.83	27.83	27.83	28.37
90	33.40	33.40	33.40	33.40	33.40	32.90

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	<37-44-**60**[2]> (35%)[3]	<37-44-**60**>[4] (35%)	<37-44-**60**> (35%)	<37-44-**60**> (35%)	<37-44-**60**> (35%)	<37-44-**60**> (35%)
80	41-47-**60** (30%)	<41-47-**60**> (30%)	<39-44-**60**> (35%)	<35-41-**60**> (35%)	<33-38-**60**> (35%)	<33-38-**59**> (35%)
90	32-38-**60** (30%)	<32-38-**60**> (30%)	<32-38-**60**> (30%)	<29-37-**59**> (35%)	<29-37-**57**> (35%)	<29-35-**57**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	37-44-**60**[2] (35%)[3]	<37-44-**60**>[4](35%)	<37-44-**60**> (35%)	<37-44-**60**> (35%)	<37-44-**60**> (35%)	<37-44-**60**> (35%)
80	41-47-**60** (30%)	<41-47-**60>** (30%)	<41-47-**60>** (30%)	<39-44-**60**> (35%)	<35-41-**60**> (35%)	<34-39-**59**> (35%)
90	32-38-**60** (30%)	34-40-**60** (30%)	<34-40-**60>** (30%)	<34-40-**60>** (30%)	<32-38-**56**> (35%)	<32-38-**56**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	45-53-**60**[2] (25%)[3]	<45-53-**60**>[4](25%)	<45-53-**60**> (25%)	<45-53-**60**> (25%)	<45-53-**60**> (25%)	<45-53-**60**> (25%)
80	41-47-**60** (30%)	41-47-**60** (30%)	<41-47-**60**> (30%)	<41-47-**60**> (30%)	<41-47-**60**> (30%)	<41-47-**60**> (30%)
90	44-49-**60** (25%)	39-51-**60** (30%)	<39-51-**60>** (30%)	<39-51-**60>** (30%)	<41-48-**59**> (25%)	<37-46-**59**> (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	45-53-**60**[2] (25%)[3]	<45-53-**60**>[4](25%)	<45-53-**60**> (25%)	<45-53-**60**> (25%)	<45-53-**60**> (25%)	<45-53-**60**> (25%)
80	41-47-**60** (30%)	41-47-**60** (30%)	<41-52-**60**> (30%)	<41-52-**60**> (30%)	<41-52-**60**> (30%)	<42-50-**60**> (25%)
90	44-49-**60** (25%)	44-49-**60** (25%)	<44-49-**60**> (25%)	<44-49-**60**> (25%)	<44-49-**60**> (25%)	<41-48-**59**> (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$39.19	-$308.80	-$375.75	-$392.84	-$397.03	-$397.79
80	$444.42	-$193.60	-$346.69	-$384.65	-$394.27	-$396.70
90	$924.73	-$73.68	-$314.33	-$374.79	-$390.54	-$395.13

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$57.89	-$257.24	-$346.60	-$375.20	-$385.68	-$390.06
80	$586.36	-$116.60	-$303.25	-$358.35	-$377.16	-$384.69
90	$1,090.09	$20.54	-$257.85	-$339.12	-$366.38	-$377.65

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$349.71	-$103.44	-$261.77	-$325.17	-$354.07	-$368.81
80	$969.61	$91.30	-$183.52	-$284.81	-$328.98	-$351.31
90	$1,573.13	$291.08	-$97.62	-$237.58	-$298.08	-$328.89

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$499.86	-$26.22	-$219.61	-$300.47	-$338.55	-$358.43
80	$1,154.14	$191.39	-$125.72	-$249.10	-$305.56	-$335.06
90	$1,811.45	$424.37	-$18.85	-$187.77	-$264.55	-$305.03

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$50.35	-$325.39	-$380.37	-$394.01	-$397.33	-$397.87
80	$571.04	-$204.00	-$350.95	-$385.80	-$394.57	-$396.79
90	$1,188.21	-$77.64	-$318.19	-$376.03	-$390.97	-$395.25

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$74.39	-$271.07	-$350.86	-$376.33	-$385.97	-$390.14
80	$753.43	-$122.86	-$306.98	-$359.42	-$377.44	-$384.78
90	$1,400.68	$21.64	-$261.02	-$340.14	-$366.82	-$377.78

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$449.35	-$109.00	-$264.99	-$326.15	-$354.33	-$368.88
80	$1,245.88	$96.20	-$185.77	-$285.66	-$329.23	-$351.38
90	$2,021.34	$306.72	-$98.82	-$238.29	-$298.33	-$328.97

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for American basswood plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$642.28	-$27.63	-$222.31	-$301.37	-$338.80	-$358.50
80	$1,482.98	$201.68	-$127.26	-$249.85	-$305.80	-$335.13
90	$2,327.56	$447.17	-$19.08	-$188.33	-$264.75	-$305.10

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for American basswood plantations by soil productivity and real alternative rates of return in the southern United States). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	37-44-**60**[3] (35%)[4]	585.16	0	620.13	0	2,127.30	2.75	3,332.59	2.75
	5.0%	37-44-**60** (35%)	585.16	0	620.13	0	2,127.30	2.75	3,332.59	2.75
	7.5%	37-44-**60** (35%)	585.16	0	620.13	0	2,127.30	2.75	3,332.59	2.75
	10.0%	37-44-**60** (35%)	585.16	0	620.13	0	2,127.30	2.75	3,332.59	2.75
	12.5%	37-44-**60** (35%)	585.16	0	620.13	0	2,127.30	2.75	3,332.59	2.75
	15.0%	37-44-**60** (35%)	585.16	0	620.13	0	2,127.30	2.75	3,332.59	2.75
80	2.5%	41-47-**60** (30%)	886.23	0	880.47	0	1,798.60	9.63	3,565.30	9.63
	5.0%	41-47-**60** (30%)	886.23	0	880.47	0	1,798.60	9.63	3,565.30	9.63
	7.5%	39-44-**60** (35%)	927.87	0	832.95	0	1,401.52	9.58	3,162.34	9.58
	10.0%	35-41-**60** (35%)	702.97	0	716.83	0	1,488.82	9.36	2,908.62	9.36
	12.5%	33-38-**60** (35%)	576.27	0	587.59	0	1,562.86	9.22	2,726.72	9.22
	15.0%	33-38-**59** (35%)	576.27	0	587.59	0	1,664.74	8.12	2,828.60	8.12
90	2.5%	32-38-**60** (30%)	654.96	0	721.71	0	1,156.07	17.46	2,532.74	17.46
	5.0%	32-38-**60** (30%)	654.96	0	721.71	0	1,156.07	17.46	2,532.74	17.46
	7.5%	32-38-**60** (30%)	654.96	0	721.71	0	1,156.07	17.46	2,532.74	17.46
	10.0%	29-37-**59** (35%)	574.47	0	743.42	0	866.75	15.69	2,184.64	15.69
	12.5%	29-37-**57** (35%)	574.47	0	743.42	0	1,140.54	13.01	2,458.43	13.01
	15.0%	29-35-**57** (35%)	574.47	0	647.64	0	1,255.97	12.36	2,478.08	12.36

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 18. Volume removed from the financially optimal schedules for American basswood plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	37-44-**60**[3] (35%)[4]	585.16	0	620.13	0	2,127.30	2.75	3,332.59	2.75
	5.0%	37-44-**60** (35%)	585.16	0	620.13	0	2,127.30	2.75	3,332.59	2.75
	7.5%	37-44-**60** (35%)	585.16	0	620.13	0	2,127.30	2.75	3,332.59	2.75
	10.0%	37-44-**60** (35%)	585.16	0	620.13	0	2,127.30	2.75	3,332.59	2.75
	12.5%	37-44-**60** (35%)	585.16	0	620.13	0	2,127.30	2.75	3,332.59	2.75
	15.0%	37-44-**60** (35%)	585.16	0	620.13	0	2,127.30	2.75	3,332.59	2.75
80	2.5%	41-47-**60** (30%)	886.23	0	880.47	0	1,798.60	9.63	3,565.30	9.63
	5.0%	41-47-**60** (30%)	886.23	0	880.47	0	1,798.60	9.63	3,565.30	9.63
	7.5%	41-47-**60** (30%)	886.23	0	880.47	0	1,798.60	9.63	3,565.30	9.63
	10.0%	39-44-**60** (35%)	927.87	0	832.95	0	1,401.52	9.58	3,162.34	9.58
	12.5%	35-41-**60** (35%)	702.97	0	716.83	0	1,488.82	9.36	2,908.62	9.36
	15.0%	34-39-**59** (35%)	660.51	0	628.86	0	1,677.02	7.86	2,966.39	7.86
90	2.5%	32-38-**60** (30%)	654.96	0	721.71	0	1,156.07	17.46	2,532.74	17.46
	5.0%	34-40-**60** (30%)	762.23	0	800.07	0	1,144.87	17.25	2,707.17	17.25
	7.5%	34-40-**60** (30%)	762.23	0	800.07	0	1,144.87	17.25	2,707.17	17.25
	10.0%	34-40-**60** (30%)	762.23	0	800.07	0	1,144.87	17.25	2,707.17	17.25
	12.5%	32-38-**56** (35%)	766.97	0	785.43	0	1,265.93	11.55	2,818.33	11.55
	15.0%	32-38-**56** (35%)	766.97	0	785.43	0	1,265.93	11.55	2,818.33	11.55

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 19. Volume removed from the financially optimal schedules for American basswood plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	45-53-**60**[3] (25%)[4]	686.79	0	786.49	0	2,973.44	1.37	4,446.72	1.37
	5.0%	45-53-**60** (25%)	686.79	0	786.49	0	2,973.44	1.37	4,446.72	1.37
	7.5%	45-53-**60** (25%)	686.79	0	786.49	0	2,973.44	1.37	4,446.72	1.37
	10.0%	45-53-**60** (25%)	686.79	0	786.49	0	2,973.44	1.37	4,446.72	1.37
	12.5%	45-53-**60** (25%)	686.79	0	786.49	0	2,973.44	1.37	4,446.72	1.37
	15.0%	45-53-**60** (25%)	686.79	0	786.49	0	2,973.44	1.37	4,446.72	1.37
80	2.5%	41-47-**60** (30%)	886.23	0	880.47	0	1,798.60	9.63	3,565.30	9.63
	5.0%	41-47-**60** (30%)	886.23	0	880.47	0	1,798.60	9.63	3,565.30	9.63
	7.5%	41-47-**60** (30%)	886.23	0	880.47	0	1,798.60	9.63	3,565.30	9.63
	10.0%	41-47-**60** (30%)	886.23	0	880.47	0	1,798.60	9.63	3,565.30	9.63
	12.5%	41-47-**60** (30%)	886.23	0	880.47	0	1,798.60	9.63	3,565.30	9.63
	15.0%	41-47-**60** (30%)	886.23	0	880.47	0	1,798.60	9.63	3,565.30	9.63
90	2.5%	44-49-**60** (25%)	1,039.80	0	999.65	0	1,348.60	16.43	3,388.05	16.43
	5.0%	39-51-**60** (30%)	1,012.06	0	1,309.01	0	1,036.57	16.47	3,357.64	16.47
	7.5%	39-51-**60** (30%)	1,012.06	0	1,309.01	0	1,036.57	16.47	3,357.64	16.47
	10.0%	39-51-**60** (30%)	1,012.06	0	1,309.01	0	1,036.57	16.47	3,357.64	16.47
	12.5%	41-48-**59** (25%)	919.85	0	992.82	0	1,671.87	14.95	3,584.54	14.95
	15.0%	37-46-**59** (25%)	764.68	0	956.68	0	2,002.63	14.39	3,723.99	14.39

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indiates no operation conducted

Table 20. Volume removed from the financially optimal schedules for American basswood plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	45-53-**60**[3] (25%)[4]	686.79	0	786.49	0	2,973.44	1.37	4,446.72	1.37
	5.0%	45-53-**60** (25%)	686.79	0	786.49	0	2,973.44	1.37	4,446.72	1.37
	7.5%	45-53-**60** (25%)	686.79	0	786.49	0	2,973.44	1.37	4,446.72	1.37
	10.0%	45-53-**60** (25%)	686.79	0	786.49	0	2,973.44	1.37	4,446.72	1.37
	12.5%	45-53-**60** (25%)	686.79	0	786.49	0	2,973.44	1.37	4,446.72	1.37
	15.0%	45-53-**60** (25%)	686.79	0	786.49	0	2,973.44	1.37	4,446.72	1.37
80	2.5%	41-47-**60** (30%)	886.23	0	880.47	0	1,798.60	9.63	3,565.30	9.63
	5.0%	41-47-**60** (30%)	886.23	0	880.47	0	1,798.60	9.63	3,565.30	9.63
	7.5%	41-52-**60** (30%)	886.23	0	1,107.23	0	1,899.54	8.91	3,893.00	8.91
	10.0%	41-52-**60** (30%)	886.23	0	1,107.23	0	1,899.54	8.91	3,893.00	8.91
	12.5%	41-52-**60** (30%)	886.23	0	1,107.23	0	1,899.54	8.91	3,893.00	8.91
	15.0%	42-50-**60** (25%)	769.82	0	884.72	0	2,505.39	8.12	4,159.93	8.12
90	2.5%	44-49-**60** (25%)	1,039.80	0	999.65	0	1,348.60	16.43	3,388.05	16.43
	5.0%	44-49-**60** (25%)	1,039.80	0	999.65	0	1,348.60	16.43	3,388.05	16.43
	7.5%	44-49-**60** (25%)	1,039.80	0	999.65	0	1,348.60	16.43	3,388.05	16.43
	10.0%	44-49-**60** (25%)	1,039.80	0	999.65	0	1,348.60	16.43	3,388.05	16.43
	12.5%	44-49-**60** (25%)	1,039.80	0	999.65	0	1,348.60	16.43	3,388.05	16.43
	15.0%	41-48-**59** (25%)	919.85	0	992.82	0	1,671.87	14.95	3,584.54	14.95

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 21. Financially optimal thinning and final harvest schedules for American basswood plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	<37-44-**60**[2]>[3] (35%)[4]	37-44-**60** (35%)	0%	45-53-**60** (25%)	0%	45-53-**60** (25%)	0%
	80	41-47-**60** (30%)	41-47-**60** (30%)	0%	41-47-**60** (30%)	0%	41-47-**60** (30%)	0%
	90	32-38-**60** (30%)	32-38-**60** (30%)	0%	44-49-**60** (25%)	0%	44-49-**60** (25%)	0%
5.00%	70	<37-44-**60**> (35%)	<37-44-**60**>(35%)	0%	<45-53-**60**>(25%)	0%	<45-53-**60**>(25%)	0%
	80	<41-47-**60**> (30%)	<41-47-**60**> (30%)	0%	41-47-**60** (30%)	0%	41-47-**60** (30%)	0%
	90	<32-38-**60**> (30%)	34-40-**60** (30%)	0%	39-51-**60** (30%)	0%	44-49-**60** (25%)	0%
7.50%	70	<37-44-**60**> (35%)	<37-44-**60**> (35%)	0%	<45-53-**60**> (25%)	0%	<45-53-**60**> (25%)	0%
	80	<39-44-**60**> (35%)	<41-47-**60**> (30%)	0%	<41-47-**60**> (30%)	0%	<41-52-**60**> (30%)	0%
	90	<32-38-**60**> (30%)	<34-40-**60**> (30%)	0%	<39-51-**60**> (30%)	0%	<44-49-**60**> (25%)	0%
10.00%	70	<37-44-**60**> (35%)	<37-44-**60**> (35%)	0%	<45-53-**60**> (25%)	0%	<45-53-**60**> (25%)	0%
	80	<35-41-**60**> (35%)	<39-44-**60**> (35%)	0%	<41-47-**60**> (30%)	0%	<41-52-**60**> (30%)	0%
	90	<29-37-**59**> (35%)	<34-40-**60**> (30%)	2%	<39-51-**60**> (30%)	2%	<44-49-**60**> (25%)	2%
12.50%	70	<37-44-**60**> (35%)	<37-44-**60**> (35%)	0%	<45-53-**60**> (25%)	0%	<45-53-**60**> (25%)	0%
	80	<33-38-**60**> (35%)	<35-41-**60**> (35%)	0%	<41-47-**60**> (30%)	0%	<41-52-**60**> (30%)	0%
	90	<29-37-**57**> (35%)	<32-38-**56**> (35%)	-2%	<41-48-**59**> (25%)	4%	<44-49-**60**> (25%)	5%
15.00%	70	<37-44-**60**> (35%)	<37-44-**60**> (35%)	0%	<45-53-**60**> (25%)	0%	<45-53-**60**> (25%)	0%
	80	<33-38-**59**> (35%)	<34-39-**59**> (35%)	0%	<41-47-**60**> (30%)	2%	<42-50-**60**> (25%)	2%
	90	<29-35-**57**> (35%)	<32-38-**56**> (35%)	-2%	<37-46-**59**> (25%)	4%	<41-48-**59**> (25%)	4%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for American basswood plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	-50.35	74.39		449.35		642.28	
	80	571.04	753.43	32%	1,245.88	118%	1,482.98	160%
	90	1,188.21	1,400.68	18%	2,021.34	70%	2,327.56	96%
5.00%	70	-325.39	-271.07		-109.00		-27.63	
	80	-204.00	-122.86		96.20		201.68	
	90	-77.64	21.64		306.72		447.17	
7.50%	70	-380.37	-350.86		-264.99		-222.31	
	80	-350.95	-306.98		-185.77		-127.26	
	90	-318.19	-261.02		-98.82		-19.08	
10.00%	70	-394.01	-376.33		-326.15		-301.37	
	80	-385.80	-359.42		-285.66		-249.85	
	90	-376.03	-340.14		-238.29		-188.33	
12.50%	70	-397.33	-385.97		-354.33		-338.80	
	80	-394.57	-377.44		-329.23		-305.80	
	90	-390.97	-366.82		-298.33		-264.75	
15.00%	70	-397.87	-390.14		-368.88		-358.50	
	80	-396.79	-384.78		-351.38		-335.13	
	90	-395.25	-377.78		-328.97		-305.10	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

Southern- American basswood - Timber Only Rotations (C = $0/ton)

American basswood, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 44 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$50.35 (Table 13), with a NPW of -$39.19 per acre (Table 9). This means that -$50.35 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$39.19 per acre for managing one rotation, or -$50.35 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,332.59 cubic feet of pulpwood and 2.75 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.00 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

American basswood, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 44 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$325.39 (Table 13), with a NPW of -$308.80 per acre (Table 9). This financially optimal rotation would produce an estimated

3,332.59 cubic feet of pulpwood and 2.75 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.00 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 44 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$380.37 (Table 13), with a NPW of -$375.75 per acre (Table 9). This financially optimal rotation would produce an estimated 3,332.59 cubic feet of pulpwood and 2.75 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.00 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 44 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$394.01 (Table 13), with a NPW of -$392.84 per acre (Table 9). This financially optimal rotation would produce an estimated 3,332.59 cubic feet of pulpwood and 2.75 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.00 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 44 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$397.33 (Table 13), with a NPW of -

$397.03 per acre (Table 9). This financially optimal rotation would produce an estimated 3,332.59 cubic feet of pulpwood and 2.75 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.00 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 44 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$397.87 (Table 13), with a NPW of -$397.79 per acre (Table 9). This financially optimal rotation would produce an estimated 3,332.59 cubic feet of pulpwood and 2.75 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.00 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of $571.04 (Table 13), with a NPW of $444.42 per acre (Table 9). This financially optimal rotation would produce an estimated 3,565.30 cubic feet of pulpwood and 9.63 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 26.96 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal

management regime will generate the maximum SEV of -$204.00 (Table 13), with a NPW of -$193.60 per acre (Table 9). This financially optimal rotation would produce an estimated 3,565.30 cubic feet of pulpwood and 9.63 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 26.96 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 44 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$350.95 (Table 13), with a NPW of -$346.69 per acre (Table 9). This financially optimal rotation would produce an estimated 3,162.34 cubic feet of pulpwood and 9.58 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 25.01 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 41 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$385.80 (Table 13), with a NPW of -$384.65 per acre (Table 9). This financially optimal rotation would produce an estimated 2,908.62 cubic feet of pulpwood and 9.36 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.58 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 38 (with 35 percent of

basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$394.57 (Table 13), with a NPW of -$394.27 per acre (Table 9). This financially optimal rotation would produce an estimated 2,726.72 cubic feet of pulpwood and 9.22 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.74 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 38 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 5). This optimal management regime will generate the maximum SEV of -$396.79 (Table 13), with a NPW of -$396.70 per acre (Table 9). This financially optimal rotation would produce an estimated 2,828.60 cubic feet of pulpwood and 8.12 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.13 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 38 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of $1,188.21 (Table 13), with a NPW of $924.73 per acre (Table 9). This financially optimal rotation would produce an estimated 2,532.74 cubic feet of pulpwood and 17.46 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 30.38 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 38 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$77.64 (Table 13), with a NPW of -$73.68 per acre (Table 9). This financially optimal rotation would produce an estimated 2,532.74 cubic feet of pulpwood and 17.46 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 30.38 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 38 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$318.19 (Table 13), with a NPW of -$314.33 per acre (Table 9). This financially optimal rotation would produce an estimated 2,532.74 cubic feet of pulpwood and 17.46 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 30.38 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 37 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 5). This optimal management regime will generate the maximum SEV of -$376.03 (Table 13), with a NPW of -$374.79 per acre (Table 9). This financially optimal rotation would produce an estimated 2,184.64 cubic feet of pulpwood and 15.69 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 26.98 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 37 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 5). This optimal management regime will generate the maximum SEV of -$390.97 (Table 13), with a NPW of -$390.54 per acre (Table 9). This financially optimal rotation would produce an estimated 2,458.43 cubic feet of pulpwood and 13.01 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 25.64 net tons of carbon per acre during one rotation (Table 1).

American basswood, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 35 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 5). This optimal management regime will generate the maximum SEV of -$395.25 (Table 13), with a NPW of -$395.13 per acre (Table 9). This financially optimal rotation would produce an estimated 2,478.08 cubic feet of pulpwood and 12.36 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 25.15 net tons of carbon per acre during one rotation (Table 1).

Southern- American basswood - Timber Only Rotations (C = $10/ton)

American basswood, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 44 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of $74.39 (Table 14), with a NPW of $57.89 per acre (Table 10). This means that $74.39 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $57.89 per acre for managing one rotation, or $74.39 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,332.59 cubic feet of pulpwood and 2.75 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.00 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

American basswood, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 44 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$271.07 (Table 14), with a NPW of -$257.24 per acre (Table 10). This financially optimal rotation would produce an estimated

3,332.59 cubic feet of pulpwood and 2.75 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.00 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 44 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$350.86 (Table 14), with a NPW of -$346.60 per acre (Table 10). This financially optimal rotation would produce an estimated 3,332.59 cubic feet of pulpwood and 2.75 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.00 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 44 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$376.33 (Table 14), with a NPW of -$375.20 per acre (Table 10). This financially optimal rotation would produce an estimated 3,332.59 cubic feet of pulpwood and 2.75 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.00 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 44 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$385.97 (Table 14), with a NPW of -

$385.68 per acre (Table 10). This financially optimal rotation would produce an estimated 3,332.59 cubic feet of pulpwood and 2.75 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.00 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 44 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$390.14 (Table 14), with a NPW of -$390.06 per acre (Table 10). This financially optimal rotation would produce an estimated 3,332.59 cubic feet of pulpwood and 2.75 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.00 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of $753.43 (Table 14), with a NPW of $586.36 per acre (Table 10). This financially optimal rotation would produce an estimated 3,565.30 cubic feet of pulpwood and 9.63 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.96 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal

management regime will generate the maximum SEV of -$122.86 (Table 14), with a NPW of -$116.60 per acre (Table 10). This financially optimal rotation would produce an estimated 3,565.30 cubic feet of pulpwood and 9.63 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.96 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$306.98 (Table 14), with a NPW of -$303.25 per acre (Table 10). This financially optimal rotation would produce an estimated 3,565.30 cubic feet of pulpwood and 9.63 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.96 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 44 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$359.42 (Table 14), with a NPW of -$358.35 per acre (Table 10). This financially optimal rotation would produce an estimated 3,162.34 cubic feet of pulpwood and 9.58 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.01 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 41 (with 35 percent of

basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$377.44 (Table 14), with a NPW of -$377.16 per acre (Table 10). This financially optimal rotation would produce an estimated 2,908.62 cubic feet of pulpwood and 9.36 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.58 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 39 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 6). This optimal management regime will generate the maximum SEV of -$384.78 (Table 14), with a NPW of -$384.69 per acre (Table 10). This financially optimal rotation would produce an estimated 2,966.39 cubic feet of pulpwood and 7.86 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.41 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 38 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of $1,400.68 (Table 14), with a NPW of $1,090.09 per acre (Table 10). This financially optimal rotation would produce an estimated 2,532.74 cubic feet of pulpwood and 17.46 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 30.38 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of $21.64 (Table 14), with a NPW of $20.54 per acre (Table 10). This financially optimal rotation would produce an estimated 2,707.17 cubic feet of pulpwood and 17.25 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 30.99 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$261.02 (Table 14), with a NPW of -$257.85 per acre (Table 10). This financially optimal rotation would produce an estimated 2,707.17 cubic feet of pulpwood and 17.25 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 30.99 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$340.14 (Table 14), with a NPW of -$339.12 per acre (Table 10). This financially optimal rotation would produce an estimated 2,707.17 cubic feet of pulpwood and 17.25 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 30.99 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 38 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 6). This optimal management regime will generate the maximum SEV of -$366.82 (Table 14), with a NPW of -$366.38 per acre (Table 10). This financially optimal rotation would produce an estimated 2,818.33 cubic feet of pulpwood and 11.55 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.78 net tons of carbon per acre during one rotation (Table 2).

American basswood, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 38 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 6). This optimal management regime will generate the maximum SEV of -$377.78 (Table 14), with a NPW of -$377.65 per acre (Table 10). This financially optimal rotation would produce an estimated 2,818.33 cubic feet of pulpwood and 11.55 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.78 net tons of carbon per acre during one rotation (Table 2).

<u>Southern- American basswood - Timber Only Rotations (C = $37/ton)</u>

American basswood, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 53 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $449.35 (Table 15), with a NPW of $349.71 per acre (Table 11). This means that $449.35 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $349.71 per acre for managing one rotation, or $449.35 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 4,446.72 cubic feet of pulpwood and 1.37 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.06 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

American basswood, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 53 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$109.00 (Table 15), with a NPW of -$103.44 per acre (Table 11). This financially optimal rotation would produce an estimated

4,446.72 cubic feet of pulpwood and 1.37 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.06 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 53 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$264.99 (Table 15), with a NPW of -$261.77 per acre (Table 11). This financially optimal rotation would produce an estimated 4,446.72 cubic feet of pulpwood and 1.37 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.06 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 53 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$326.15 (Table 15), with a NPW of -$325.17 per acre (Table 11). This financially optimal rotation would produce an estimated 4,446.72 cubic feet of pulpwood and 1.37 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.06 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 53 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$354.33 (Table 15), with a NPW of -

$354.07 per acre (Table 11). This financially optimal rotation would produce an estimated 4,446.72 cubic feet of pulpwood and 1.37 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.06 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 53 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$368.88 (Table 15), with a NPW of -$368.81 per acre (Table 11). This financially optimal rotation would produce an estimated 4,446.72 cubic feet of pulpwood and 1.37 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.06 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $1,245.88 (Table 15), with a NPW of $969.61 per acre (Table 11). This financially optimal rotation would produce an estimated 3,565.30 cubic feet of pulpwood and 9.63 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.96 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal

management regime will generate the maximum SEV of $96.20 (Table 15), with a NPW of $91.30 per acre (Table 11). This financially optimal rotation would produce an estimated 3,565.30 cubic feet of pulpwood and 9.63 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.96 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$185.77 (Table 15), with a NPW of -$183.52 per acre (Table 11). This financially optimal rotation would produce an estimated 3,565.30 cubic feet of pulpwood and 9.63 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.96 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$285.66 (Table 15), with a NPW of -$284.81 per acre (Table 11). This financially optimal rotation would produce an estimated 3,565.30 cubic feet of pulpwood and 9.63 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.96 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$329.23 (Table 15), with a NPW of -$328.98 per acre (Table 11). This financially optimal rotation would produce an estimated 3,565.30 cubic feet of pulpwood and 9.63 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.96 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$351.38 (Table 15), with a NPW of -$351.31 per acre (Table 11). This financially optimal rotation would produce an estimated 3,565.30 cubic feet of pulpwood and 9.63 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.96 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 49 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $2,021.34 (Table 15), with a NPW of $1,573.13 per acre (Table 11). This financially optimal rotation would produce an estimated 3,388.05 cubic feet of pulpwood and 16.43 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 33.40 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $306.72 (Table 15), with a NPW of $291.08 per acre (Table 11). This financially optimal rotation would produce an estimated 3,357.64 cubic feet of pulpwood and 16.47 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 33.31 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$98.82 (Table 15), with a NPW of -$97.62 per acre (Table 11). This financially optimal rotation would produce an estimated 3,357.64 cubic feet of pulpwood and 16.47 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 33.31 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$238.29 (Table 15), with a NPW of -$237.58 per acre (Table 11). This financially optimal rotation would produce an estimated 3,357.64 cubic feet of pulpwood and 16.47 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 33.31 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 48 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 7). This optimal management regime will generate the maximum SEV of -$298.33 (Table 15), with a NPW of -$298.08 per acre (Table 11). This financially optimal rotation would produce an estimated 3,584.54 cubic feet of pulpwood and 14.95 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 32.90 net tons of carbon per acre during one rotation (Table 3).

American basswood, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 46 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 7). This optimal management regime will generate the maximum SEV of -$328.97 (Table 15), with a NPW of -$328.89 per acre (Table 11). This financially optimal rotation would produce an estimated 3,723.99 cubic feet of pulpwood and 14.39 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 33.09 net tons of carbon per acre during one rotation (Table 3).

Southern- American basswood - Timber Only Rotations (C = $50/ton)

American basswood, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 53 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $642.28 (Table 16), with a NPW of $499.86 per acre (Table 12). This means that $642.28 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$499.86 per acre for managing one rotation, or $642.28 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 4,446.72 cubic feet of pulpwood and 1.37 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.06 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

American basswood, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 53 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$27.63 (Table 16), with a NPW of -$26.22 per acre (Table 12). This financially optimal rotation would produce an estimated

4,446.72 cubic feet of pulpwood and 1.37 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.06 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 53 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$222.31 (Table 16), with a NPW of -$219.61 per acre (Table 12). This financially optimal rotation would produce an estimated 4,446.72 cubic feet of pulpwood and 1.37 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.06 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 53 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$301.37 (Table 16), with a NPW of -$300.47 per acre (Table 12). This financially optimal rotation would produce an estimated 4,446.72 cubic feet of pulpwood and 1.37 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.06 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 53 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$338.80 (Table 16), with a NPW of -

$338.55 per acre (Table 12). This financially optimal rotation would produce an estimated 4,446.72 cubic feet of pulpwood and 1.37 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.06 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 53 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$358.50 (Table 16), with a NPW of -$358.43 per acre (Table 12). This financially optimal rotation would produce an estimated 4,446.72 cubic feet of pulpwood and 1.37 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.06 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $1,482.98 (Table 16), with a NPW of $1,154.14 per acre (Table 12). This financially optimal rotation would produce an estimated 3,565.30 cubic feet of pulpwood and 9.63 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 26.96 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal

management regime will generate the maximum SEV of $201.68 (Table 16), with a NPW of $191.39 per acre (Table 12). This financially optimal rotation would produce an estimated 3,565.30 cubic feet of pulpwood and 9.63 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 26.96 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$127.26 (Table 16), with a NPW of -$125.72 per acre (Table 12). This financially optimal rotation would produce an estimated 3,893.00 cubic feet of pulpwood and 8.91 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 27.83 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$249.85 (Table 16), with a NPW of -$249.10 per acre (Table 12). This financially optimal rotation would produce an estimated 3,893.00 cubic feet of pulpwood and 8.91 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 27.83 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 52 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$305.80 (Table 16), with a NPW of -$305.56 per acre (Table 12). This financially optimal rotation would produce an estimated 3,893.00 cubic feet of pulpwood and 8.91 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 27.83 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 50 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$335.13 (Table 16), with a NPW of -$335.06 per acre (Table 12). This financially optimal rotation would produce an estimated 4,159.93 cubic feet of pulpwood and 8.12 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 28.37 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 49 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $2,327.56 (Table 16), with a NPW of $1,811.45 per acre (Table 12). This financially optimal rotation would produce an estimated 3,388.05 cubic feet of pulpwood and 16.43 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 33.40 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 49 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $447.17 (Table 16), with a NPW of $424.37 per acre (Table 12). This financially optimal rotation would produce an estimated 3,388.05 cubic feet of pulpwood and 16.43 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 33.40 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 49 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$19.08 (Table 16), with a NPW of -$18.85 per acre (Table 12). This financially optimal rotation would produce an estimated 3,388.05 cubic feet of pulpwood and 16.43 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 33.40 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 49 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$188.33 (Table 16), with a NPW of -$187.77 per acre (Table 12). This financially optimal rotation would produce an estimated 3,388.05 cubic feet of pulpwood and 16.43 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 33.40 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 49 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$264.75 (Table 16), with a NPW of -$264.55 per acre (Table 12). This financially optimal rotation would produce an estimated 3,388.05 cubic feet of pulpwood and 16.43 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 33.40 net tons of carbon per acre during one rotation (Table 4).

American basswood, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 48 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 8). This optimal management regime will generate the maximum SEV of -$305.10 (Table 16), with a NPW of -$305.03 per acre (Table 12). This financially optimal rotation would produce an estimated 3,584.54 cubic feet of pulpwood and 14.95 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 32.90 net tons of carbon per acre during one rotation (Table 4).

American beech (*Fagus grandifolia*)

Biological Information

American beech is the only species of its genus in North America. It attains its best growth in the Mississippi and Ohio River valleys, and can attain ages of 300 to 400 years. The range of American beech extends from Nova Scotia south to the panhandle of Florida west to Eastern Texas and north to eastern Wisconsin (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/fagus/grandifolia.htm. May 9, 2006) (Fig. 1).

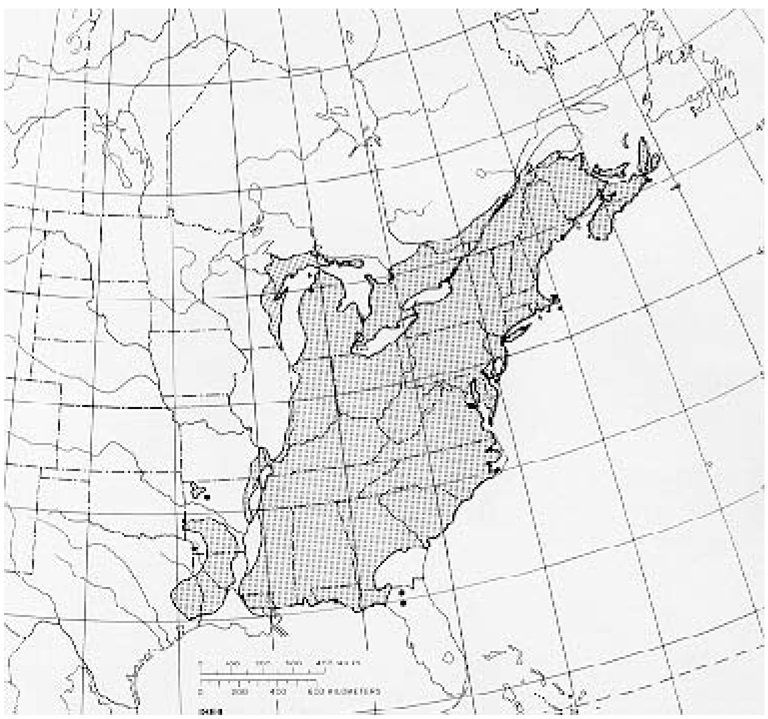

Fig. 1. The native range of American beech (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/fagus/grandifolia.htm. May 9, 2006)

The height range of white ash at maturity is typically from 60 to 80 feet. Average annual diameter increments range from 0.15 to 0.19 inches in trees released by thinning. Under optimum conditions beech trees may reach 120 feet in height. Fully stocked stands exhibit self-pruning, however stand thinnings often result in a profusion of epicormic branching. American beech is classed as very tolerant of shade, and is recognized as a climax species in the northern hardwood types (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/fagus/grandifolia.htm. May 9, 2006).

American beech is the only nut producer in the northern hardwood type, and people and wildlife eat its nuts. The wood is used for flooring, furniture, turned products, novelties, plywood, veneer, baskets, pulp, railroad ties, charcoal, and lumber. Creosote made from the wood is used both externally and internally as a medicine for a variety of human and animal disorders (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/fagus/grandifolia.htm. May 9, 2006).

Miller (1997) analyzed stand dynamics in 60-year-old-Allegheny hardwoods after thinning. The objective was to quantify the effect of manipulating relative stand density (RD) on stand dynamics over a ten-year period. Thinnings were conducted in 60-year-old stands to include four treatments: 45, 60, 75 percent RD, and control. Average RD before thinning was 110%, and mortality in lower crown positions was evident. In general ingrowth increased and mortality decreased as RD decreased. Results indicated that greater increases in net cubic volume growth are obtained by thinning to between 60 and 75 percent RD, peaking at about 70% RD. Sawtimber volume growth peaked where 78% of the trees removed were smaller than the medial stand diameter.

Literature Cited

Miller G.W. 1997. Stand dynamics in 60-year-old- Allegheny hardwoods after thinning. Can. J. For. Res. 27: 1645-1657.

Species American beech Region Northeast

Site indices 60, 70 and 80 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 4.80, 5.70, and 8.20 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 20 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183628319 and 0.553097345, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Whittaker et al. (1974) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$\text{Log}_{10}(y) = 2.2916+2.3916\ln(x)$$

where:

y = dry-weight (g.) aboveground with leaves

x = diameter at breast height (cm.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisors 200X). The price of sawtimber was assumed to be $45/mbf (International 1/4) (WVU Division of Forestry, http://ahc.caf.wvu.edu/., University of Maryland, http://www.naturalresources.umd.edu/Stumpage_Prices.cfm., Universities of Connecticut and Massachusetts, http://forest.fnr.umass.edu/snestumpage.htm., University of Vermont Extension, http://stumpage.uvm.edu/stumpage.php., Maine Department of Conservation, http://www.state.me.us/doc/mfs/pubs.htm. February 3, 2006) and pulpwood price was assumed to be $8.66/cord (WVU Division of Forestry, http://ahc.caf.wvu.edu/., University of Maryland, http://www.naturalresources.umd.edu/Stumpage_Prices.cfm., Universities of Connecticut and Massachusetts, http://forest.fnr.umass.edu/snestumpage.htm., University of Vermont Extension, http://stumpage.uvm.edu/stumpage.php., Maine Department of Conservation, http://www.state.me.us/doc/mfs/pubs.htm. February 3, 2006). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of American beech plantations in the Northeast.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$218.00	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]Data from Gary D. Kronrad, personal communications, Stephen F. Austin State University, February 8, 2005.

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Table 1. Total tons of carbon sequestered per acre for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	37.52	36.92	34.80	41.06	41.09	40.71
70	40.84	38.83	42.47	42.47	42.47	42.76
80	46.82	46.82	44.46	43.85	43.85	43.85

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	37.52	37.52	37.52	37.52	37.52	37.52
70	40.84	40.84	40.84	40.61	40.61	40.61
80	46.82	40.47	40.47	40.51	40.51	40.51

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	37.52	37.52	37.52	37.52	37.52	37.52
70	40.84	40.84	40.84	40.84	40.84	40.84
80	40.47	40.51	40.51	40.51	40.51	40.51

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	37.52	37.52	37.52	37.52	37.52	37.52
70	40.84	40.84	40.84	40.84	40.84	40.84
80	40.51	40.51	40.51	40.51	40.51	40.51

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<**90**[2]>[3]	<**88**>	<**82**>	<60-66-**90**> (30%)[4]	<60-66-**90**> (30%)	<59-66-**89**> (30%)
70	<**90**>	<**85**>	<36-50-**90**> (30%)	<36-50-**90**> (30%)	<36-50-**90**> (30%)	<36-50-**89**> (30%)
80	<31-38-**90**> (30%)	<31-38-**90**> (30%)	<30-36-**85**> (30%)	<30-36-**83**> (30%)	<30-36-**83**> (30%)	<30-36-**83**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<**90**[2]>[3]	<**90**>	<**90**>	<**90**>	<**90**>	<**90**>
70	<**90**>	<**90**>	<**90**>	<**89**>	<**89**>	<**89**>
80	<31-38-**90>** (30%)[4]	<**89**>	<**89**>	<**90**>	<**90**>	<**90**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	**90**[2]	**90**	**90**	**<90>**[3]	**<90>**	**<90>**
70	**90**	**90**	**90**	**<90>**	**<90>**	**<90>**
80	**89**	**90**	**90**	**<90>**	**<90>**	**<90>**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	**90**[2]	**90**	**90**	**90**	**<90>**[3]	**<90>**
70	**90**	**90**	**90**	**90**	**<90>**	**<90>**
80	**90**	**90**	**90**	**90**	**90**	**<90>**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$399.92	-$466.57	-$469.22	-$467.41	-$465.58	-$464.35
70	-$376.08	-$462.90	-$467.43	-$466.20	-$465.03	-$464.11
80	-$397.39	-$457.26	-$463.63	-$464.42	-$464.13	-$463.63

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$98.49	-$274.70	-$339.36	-$372.74	-$393.08	-$406.62
70	-$39.87	-$245.46	-$318.87	-$356.99	-$380.56	-$396.44
80	-$48.34	-$225.79	-$299.86	-$341.20	-$367.51	-$385.53

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$715.36	-$245.29	$12.91	$116.95	-$197.25	-$250.70
70	$867.88	$346.12	$87.85	-$58.80	-$150.93	-$213.05
80	$921.70	$430.08	$159.51	-$0.19	-$102.63	-$172.69

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$1,107.22	$495.66	$182.52	$6.21	-$102.96	-$175.64
70	$1,304.95	$630.96	$283.68	$84.78	-$40.37	-$124.75
80	$1,394.81	$745.96	$380.70	$164.01	$24.91	-$70.21

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$447.19	-$472.72	-$470.38	-$467.49	-$465.59	-$464.35
70	-$420.53	-$469.98	-$468.08	-$466.28	-$465.05	-$464.11
80	-$444.36	-$462.72	-$464.55	-$464.58	-$464.16	-$463.63

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$110.13	-$277.98	-$339.83	-$372.80	-$393.09	-$406.62
70	-$44.59	-$248.39	-$319.31	-$357.05	-$380.57	-$396.44
80	-$54.06	-$228.62	-$300.30	-$341.26	-$367.52	-$385.53

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$799.92	$248.22	$12.93	-$116.97	-$197.25	-$250.71
70	$970.47	$350.25	$87.97	-$58.81	-$150.94	-$213.05
80	$1,033.71	$435.21	$159.73	-$0.19	-$102.63	-$172.69

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for American beech plantations by site index and real alternative rates of return in the northeastern region of the United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$1,238.10	$501.58	$182.77	$6.21	-$102.96	-$175.64
70	$1,459.20	$638.49	$284.07	$84.79	-$40.37	-$124.75
80	$1,559.69	$754.86	$381.23	$164.03	$24.91	-$70.21

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for American beech plantations by soil productivity and real alternative rates of return in the northeastern region of the United States). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	**90**[3]	-[4]	-	-	-	2,743.09	2.39	2,739.09	2.39
	5.0%	**88**	-	-	-	-	2,711.94	2.30	2,711.94	2.30
	7.5%	**82**	-	-	-	-	2,616.11	2.00	2,616.11	2.00
	10.0%	60-66-**90** (30%)[5]	635.61	0	559.63	0	1,843.86	2.48	3,039.10	2.48
	12.5%	60-66-**90** (30%)	635.61	0	559.63	0	1,843.86	2.48	3,039.10	2.48
	15.0%	59-66-**89** (30%)	557.39	0	561.31	0	1,825.13	2.42	2,943.83	2.42
70	2.5%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
	5.0%	**85**	-	-	-	-	3,292.62	2.61	3,292.62	2.61
	7.5%	36-50-**90** (30%)	571.55	0	558.65	0	2,999.72	0	4,129.92	0
	10.0%	36-50-**90** (30%)	571.55	0	558.65	0	2,999.72	0	4,129.92	0
	12.5%	36-50-**90** (30%)	571.55	0	558.65	0	2,999.72	0	4,129.92	0
	15.0%	36-50-**89** (30%)	571.55	0	558.65	0	3,000.05	0	4,130.25	0
80	2.5%	31-38-**90** (30%)	569.10	0	579.82	0	2,025.24	11.02	3,174.16	11.02
	5.0%	31-38-**90** (30%)	569.10	0	579.82	0	2,025.24	11.02	3,174.16	11.02
	7.5%	30-36-**85** (30%)	554.65	0	554.27	0	2,129.07	8.83	3,237.99	8.83
	10.0%	30-36-**83** (30%)	554.65	0	554.27	0	2,002.29	8.66	3,111.21	8.66
	12.5%	30-36-**83** (30%)	554.65	0	554.27	0	2,002.29	8.66	3,111.21	8.66
	15.0%	30-36-**83** (30%)	554.65	0	554.27	0	2,002.29	8.66	3,111.21	8.66

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Indicates no operation conducted.
[5]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 18. Volume removed from the financially optimal schedules for American beech plantations by soil productivity and real alternative rates of return in the northeastern region of the United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	**90**[3]	-[4]	-	-	-	2,743.09	2.39	2,743.09	2.39
	5.0%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
	7.5%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
	10.0%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
	12.5%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
	15.0%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
70	2.5%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
	5.0%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
	7.5%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
	10.0%	**89**	-	-	-	-	3,354.41	2.88	3,354.41	2.88
	12.5%	**89**	-	-	-	-	3,354.41	2.88	3,354.41	2.88
	15.0%	**89**	-	-	-	-	3,354.41	2.88	3,354.41	2.88
80	2.5%	31-38-**90** (30%)[5]	569.10	0	579.82	0	2,025.24	11.02	3,174.16	11.02
	5.0%	**89**	-	-	-	-	4,174.97	0	4,174.97	0
	7.5%	**89**	-	-	-	-	4,174.97	0	4,174.97	0
	10.0%	**90**	-	-	-	-	4,204.50	0	4,204.50	0
	12.5%	**90**	-	-	-	-	4,204.50	0	4,204.50	0
	15.0%	**90**	-	-	-	-	4,204.50	0	4,204.50	0

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Indicates no operation conducted.
[5]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 19. Volume removed from the financially optimal schedules for American beech plantations by soil productivity and real alternative rates of return in the northeastern region of the United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	**90**[3]	-[4]	-	-	-	2,743.09	2.39	2,743.09	2.39
	5.0%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
	7.5%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
	10.0%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
	12.5%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
	15.0%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
70	2.5%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
	5.0%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
	7.5%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
	10.0%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
	12.5%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
	15.0%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
80	2.5%	**89**	-	-	-	-	4,174.97	0	4,174.97	0
	5.0%	**90**	-	-	-	-	4,204.50	0	4,204.50	0
	7.5%	**90**	-	-	-	-	4,204.50	0	4,204.50	0
	10.0%	**90**	-	-	-	-	4,204.50	0	4,204.50	0
	12.5%	**90**	-	-	-	-	4,204.50	0	4,204.50	0
	15.0%	**90**	-	-	-	-	4,204.50	0	4,204.50	0

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for American beech plantations by soil productivity and real alternative rates of return in the northeastern region of the United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	**90**[3]	-[4]	-	-	-	2,743.09	2.39	2,743.09	2.39
	5.0%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
	7.5%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
	10.0%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
	12.5%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
	15.0%	**90**	-	-	-	-	2,743.09	2.39	2,743.09	2.39
70	2.5%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
	5.0%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
	7.5%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
	10.0%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
	12.5%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
	15.0%	**90**	-	-	-	-	3,423.19	2.95	3,423.19	2.95
80	2.5%	**90**	-	-	-	-	4,204.50	0	4,204.50	0
	5.0%	**90**	-	-	-	-	4,204.50	0	4,204.50	0
	7.5%	**90**	-	-	-	-	4,204.50	0	4,204.50	0
	10.0%	**90**	-	-	-	-	4,204.50	0	4,204.50	0
	12.5%	**90**	-	-	-	-	4,204.50	0	4,204.50	0
	15.0%	**90**	-	-	-	-	4,204.50	0	4,204.50	0

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for American beech plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	60	<**90**[2]>[3]	<**90**>	0%	**90**	0%	**90**	0%
	70	<**90**>	<**90**>	0%	**90**	0%	**90**	0%
	80	<31-38-**90**> (30%)[4]	<31-38-**90**> (30%)	0%	**89**	-1%	**90**	0%
5.00%	60	<**88**>	<**90**>	2%	**90**	2%	**90**	2%
	70	<**85**>	<**90**>	6%	**90**	6%	**90**	6%
	80	<31-38-**90**> (30%)	<**89**>	-1%	**90**	0%	**90**	0%
7.50%	60	<**82**>	<**90**>	10%	**90**	10%	**90**	10%
	70	<36-50-**90**> (30%)	<**90**>	0%	**90**	0%	**90**	0%
	80	<30-36-**85**> (30%)	<**89**>	5%	**90**	6%	**90**	6%
10.00%	60	<60-66-**90**> (30%)	<**90**>	0%	**<90>**	0%	**90**	0%
	70	<36-50-**90**> (30%)	<**89**>	-1%	**<90>**	0%	**90**	0%
	80	<30-36-**83**> (30%)	<**90**>	8%	**<90>**	8%	**90**	8%
12.50%	60	<60-66-**90**> (30%)	<**90**>	0%	**<90>**	0%	**<90>**	0%
	70	<36-50-**90**> (30%)	<**89**>	-1%	**<90>**	0%	**<90>**	0%
	80	<30-36-**83**> (30%)	<**90**>	8%	**<90>**	8%	**90**	8%
15.00%	60	<59-66-**89**> (30%)	<**90**>	1%	**<90>**	1%	**<90>**	1%
	70	<36-50-**89**> (30%)	<**89**>	0%	**<90>**	1%	**<90>**	1%
	80	<30-36-**83**> (30%)	<**90**>	8%	**<90>**	8%	**<90>**	8%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for American beech plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	60	-447.19	-110.13		799.92		1,238.10	
	70	-420.53	-44.59		970.47		1,459.20	
	80	-444.36	-54.06		1,033.71		1,559.69	
5.00%	60	-472.72	-277.98		248.22		501.58	
	70	-469.98	-248.39		350.25		638.49	
	80	-462.72	-228.62		435.21		754.86	
7.50%	60	-470.38	-339.83		12.93		182.77	
	70	-468.08	-319.31		87.97		284.07	
	80	-464.55	-300.30		159.73		381.23	
10.00%	60	-467.49	-372.80		-116.97		6.21	
	70	-466.28	-357.05		-58.81		84.79	
	80	-464.58	-341.26		-0.19		164.03	
12.50%	60	-465.59	-393.09		-197.25		-102.96	
	70	-465.05	-380.57		-150.94		-40.37	
	80	-464.16	-367.52		-102.63		24.91	
15.00%	60	-464.35	-406.62		-250.71		-175.64	
	70	-464.11	-396.44		-213.05		-124.75	
	80	-463.63	-385.53		-172.69		-70.21	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

Northeast- American beech - Timber Only Rotations (C = $0/ton)

American beech, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$447.19 (Table 13), with a NPW of -$399.92 per acre (Table 9). This means that -$447.19 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$399.92 per acre for managing one rotation, or -$447.19 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,739.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 37.52 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

American beech, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 88 (Table 5). This optimal management regime will generate the maximum SEV of -$472.19 (Table 13), with a NPW of -$466.57 per acre (Table 9). This financially optimal rotation would produce an estimated 2,711.94 cubic feet of pulpwood and 2.30 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 36.92 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 82 (Table 5). This optimal management regime will generate the maximum SEV of -$470.38 (Table 13), with a NPW of -$469.22 per acre (Table 9). This financially optimal rotation would produce an estimated 2,616.11 cubic feet of pulpwood and 2.00 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 34.80 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 66 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$467.49 (Table 13), with a NPW of -$467.41 per acre (Table 9). This financially optimal rotation would produce an estimated 3,039.10 cubic feet of pulpwood and 2.48 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 41.06 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 66 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$465.59 (Table 13), with a NPW of -$465.58 per acre (Table 9). This financially optimal rotation would produce an estimated 3,039.10 cubic feet of pulpwood and 2.48 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 41.06 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 59 and 66 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 5). This optimal management regime will generate the maximum SEV of -$464.35 (Table 13), with a NPW of -$464.35 per acre (Table 9). This financially optimal rotation would produce an estimated 2,943.83 cubic feet of pulpwood and 2.42 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 40.71 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$420.53 (Table 13), with a NPW of -$376.08 per acre (Table 9). This financially optimal rotation would produce an estimated 3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 40.84 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 85 (Table 5). This optimal management regime will generate the maximum SEV of -$469.98 (Table 13), with a NPW of -$462.90 per acre (Table 9). This financially optimal rotation would produce an estimated 3,292.62 cubic feet of pulpwood and 2.61 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 38.83 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 50 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$468.08 (Table 13), with a NPW of -$467.43 per acre (Table 9). This financially optimal rotation would produce an estimated 4,129.92 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 42.47 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 50 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$466.28 (Table 13), with a NPW of -$466.20 per acre (Table 9). This financially optimal rotation would produce an estimated 4,129.92 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 42.47 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$465.05 (Table 13), with a NPW of -$465.03 per acre (Table 9). This financially optimal rotation would produce an estimated 4,129.92 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 42.47 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 50 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 5). This optimal management regime will generate the maximum SEV of -$464.11 (Table 13), with a NPW of -$464.11 per acre (Table 9). This financially optimal rotation would produce an estimated 4,130.25 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 42.76 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 38 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$444.36 (Table 13), with a NPW of -$397.39 per acre (Table 9). This financially optimal rotation would produce an estimated 3,174.16 cubic feet of pulpwood and 11.02 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 46.82 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 38 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$462.72 (Table 13), with a NPW of -$457.26 per acre (Table 9). This financially optimal rotation would produce an estimated

3,174.16 cubic feet of pulpwood and 11.02 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 46.82 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 36 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 5). This optimal management regime will generate the maximum SEV of -$464.55 (Table 13), with a NPW of -$463.63 per acre (Table 9). This financially optimal rotation would produce an estimated 3,237.99 cubic feet of pulpwood and 8.83 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 44.46 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 36 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 5). This optimal management regime will generate the maximum SEV of -$464.58 (Table 13), with a NPW of -$464.42 per acre (Table 9). This financially optimal rotation would produce an estimated 3,111.21 cubic feet of pulpwood and 8.66 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 43.85 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 36 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 5). This optimal management regime will generate the maximum SEV of -$464.16 (Table 13), with a NPW of -

$464.13 per acre (Table 9). This financially optimal rotation would produce an estimated 3,111.21 cubic feet of pulpwood and 8.66 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 43.85 net tons of carbon per acre during one rotation (Table 1).

American beech, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 36 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 5). This optimal management regime will generate the maximum SEV of -$463.63 (Table 13), with a NPW of -$463.63 per acre (Table 9). This financially optimal rotation would produce an estimated 3,111.21 cubic feet of pulpwood and 8.66 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 43.85 net tons of carbon per acre during one rotation (Table 1).

<u>Northeast- American beech - Timber Only Rotations (C = $10/ton)</u>

American beech, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$110.13 (Table 14), with a NPW of -$98.49 per acre (Table 10). This means that -$110.13 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$98.49 per acre for managing one rotation, or -$110.13 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 37.52 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

American beech, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$277.98 (Table 14), with a NPW of -$274.70 per acre (Table 10). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 37.52 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$339.83 (Table 14), with a NPW of -$339.36 per acre (Table 10). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 37.52 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$372.80 (Table 14), with a NPW of -$372.74 per acre (Table 10). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 37.52 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$393.09 (Table 14), with a NPW of -$393.08 per acre (Table 10). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 37.52 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$406.62 (Table 14), with a NPW of -$406.62 per acre (Table 10). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 37.52 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$44.59 (Table 14), with a NPW of -$39.87 per acre (Table 10). This financially optimal rotation would produce an estimated 3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.84 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$248.39 (Table 14), with a NPW of -$245.46 per acre (Table 10). This financially optimal rotation would produce an estimated 3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.84 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 6). This optimal

management regime will generate the maximum SEV of -$319.31 (Table 14), with a NPW of -$318.87 per acre (Table 10). This financially optimal rotation would produce an estimated 3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.84 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$357.05 (Table 14), with a NPW of -$356.99 per acre (Table 10). This financially optimal rotation would produce an estimated 3,354.41 cubic feet of pulpwood and 2.88 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.61 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$380.57 (Table 14), with a NPW of -$380.56 per acre (Table 10). This financially optimal rotation would produce an estimated 3,354.41 cubic feet of pulpwood and 2.88 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.61 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$396.44 (Table 14), with a NPW of -$396.44 per acre (Table 10). This financially optimal rotation would produce an estimated

3,354.41 cubic feet of pulpwood and 2.88 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.61 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 38 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$54.06 (Table 14), with a NPW of -$48.34 per acre (Table 10). This financially optimal rotation would produce an estimated 3,174.16 cubic feet of pulpwood and 11.02 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 46.82 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$228.62 (Table 14), with a NPW of -$225.79 per acre (Table 10). This financially optimal rotation would produce an estimated 4,174.97 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.47 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$300.30 (Table 14), with a NPW of -$299.86 per acre (Table 10). This financially optimal rotation would produce an estimated

4,174.97 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.47 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$341.26 (Table 14), with a NPW of -$341.20 per acre (Table 10). This financially optimal rotation would produce an estimated 4,204.50 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.51 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$367.52 (Table 14), with a NPW of -$367.51 per acre (Table 10). This financially optimal rotation would produce an estimated 4,204.50 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.51 net tons of carbon per acre during one rotation (Table 2).

American beech, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$385.53 (Table 14), with a NPW of -$385.53 per acre (Table 10). This financially optimal rotation would produce an estimated 4,204.50 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.51 net tons of carbon per acre during one rotation (Table 2).

Northeast-American beech - Timber Only Rotations (C = $37/ton)

American beech, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $799.92 (Table 15), with a NPW of $715.36 per acre (Table 11). This means that $799.92 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $715.36 per acre for managing one rotation, or $799.92 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 37.52 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

American beech, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $248.22 (Table 15), with a NPW of $245.29 per acre (Table 11). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 37.52 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $12.93 (Table 15), with a NPW of $12.91 per acre (Table 11). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 37.52 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$116.97 (Table 15), with a NPW of -$116.95 per acre (Table 11). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 37.52 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$197.25 (Table 15), with a NPW of -$197.25 per acre (Table 11). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 37.52 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal

management regime will generate the maximum SEV of -$250.71 (Table 15), with a NPW of -$250.70 per acre (Table 11). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 37.52 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $970.47 (Table 15), with a NPW of $867.88 per acre (Table 11). This financially optimal rotation would produce an estimated 3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.84 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $350.25 (Table 15), with a NPW of $346.12 per acre (Table 11). This financially optimal rotation would produce an estimated 3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.84 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $87.97 (Table 15), with a NPW of $87.85 per acre (Table 11). This financially optimal rotation would produce an estimated

3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.84 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$58.81 (Table 15), with a NPW of -$58.80 per acre (Table 11). This financially optimal rotation would produce an estimated 3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.84 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$150.94 (Table 15), with a NPW of -$150.93 per acre (Table 11). This financially optimal rotation would produce an estimated 3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.84 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$213.05 (Table 15), with a NPW of -$213.05 per acre (Table 11). This financially optimal rotation would produce an estimated 3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.84 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of $1,033.71 (Table 15), with a NPW of $921.70 per acre (Table 11). This financially optimal rotation would produce an estimated 4,174.97 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.47 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $435.21 (Table 15), with a NPW of $430.08 per acre (Table 11). This financially optimal rotation would produce an estimated 4,204.50 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.51 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $159.73 (Table 15), with a NPW of $159.51 per acre (Table 11). This financially optimal rotation would produce an estimated 4,204.50 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.51 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$0.19 (Table 15), with a NPW of -$0.19 per acre (Table 11). This financially optimal rotation would produce an estimated 4,204.50 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.51 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$102.63 (Table 15), with a NPW of -$102.63 per acre (Table 11). This financially optimal rotation would produce an estimated 4,204.50 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.51 net tons of carbon per acre during one rotation (Table 3).

American beech, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$172.69 (Table 15), with a NPW of -$172.69 per acre (Table 11). This financially optimal rotation would produce an estimated 4,204.50 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.51 net tons of carbon per acre during one rotation (Table 3).

Northeast- American beech - Timber Only Rotations (C = $50/ton)

American beech, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $1,238.10 (Table 16), with a NPW of $1,107.22 per acre (Table12). This means that $1,238.10 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,107.22 per acre for managing one rotation, or $1,238.10 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 37.52 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

American beech, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age909 (Table 8). This optimal management regime will generate the maximum SEV of $501.58 (Table 16), with a NPW of $495.66 per acre (Table 12). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 37.52 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $182.77 (Table 16), with a NPW of $182.52 per acre (Table 12). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 37.52 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $6.21 (Table 16), with a NPW of $6.21 per acre (Table 12). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 37.52 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$102.96 (Table 16), with a NPW of -$102.96 per acre (Table 12). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 37.52 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal

management regime will generate the maximum SEV of -$175.64 (Table 16), with a NPW of -$175.64 per acre (Table 12). This financially optimal rotation would produce an estimated 2,743.09 cubic feet of pulpwood and 2.39 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 37.52 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $1,459.20 (Table 16), with a NPW of $1,304.95 per acre (Table 12). This financially optimal rotation would produce an estimated 3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.84 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $638.49 (Table 16), with a NPW of $630.96 per acre (Table 12). This financially optimal rotation would produce an estimated 3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.84 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $284.07 (Table 16), with a NPW of $283.68 per acre (Table 12). This financially optimal rotation would produce an estimated

3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.84 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $84.79 (Table 16), with a NPW of $84.78 per acre (Table 12). This financially optimal rotation would produce an estimated 3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.84 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$40.37 (Table 16), with a NPW of -$40.37 per acre (Table 12). This financially optimal rotation would produce an estimated 3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.84 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$124.75 (Table 16), with a NPW of -$124.75 per acre (Table 12). This financially optimal rotation would produce an estimated 3,423.19 cubic feet of pulpwood and 2.95 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.84 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $1,559.69 (Table 16), with a NPW of $1,394.81 per acre (Table 12). This financially optimal rotation would produce an estimated 4,204.50 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.51 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $754.86 (Table 16), with a NPW of $745.96 per acre (Table 12). This financially optimal rotation would produce an estimated 4,204.50 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.51 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $381.23 (Table 16), with a NPW of $380.70 per acre (Table 12). This financially optimal rotation would produce an estimated 4,204.50 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.51 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $164.03 (Table 16), with a NPW of -$164.01 per acre (Table 12). This financially optimal rotation would produce an estimated 4,204.50 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.51 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $24.91 (Table 16), with a NPW of -$24.91 per acre (Table 12). This financially optimal rotation would produce an estimated 4,204.50 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.51 net tons of carbon per acre during one rotation (Table 4).

American beech, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$70.21 (Table 16), with a NPW of -$70.21 per acre (Table 12). This financially optimal rotation would produce an estimated 4,204.50 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.51 net tons of carbon per acre during one rotation (Table 4).

Black ash - *Fraxinus nigra* Marsh.

Biological information

Black ash, also named swamp ash, basket ash, brown ash, hoop ash, and water ash, the only native ash to Newfoundland. As a small, slow-growing tree of northern swampy woodlands, it has never been commercially important (Silvics Manual, USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/fraxinus/nigra.htm. June 10, 2006).

Black ash grows naturally from western Newfoundland and west to Manitoba and North Dakota; south to Iowa; east to southern Indiana, Ohio, and west Virginia; and north to Virginia, Delaware and New Jersey (Silvics Manual, USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/fraxinus/nigra.htm. June 10, 2006) (Fig. 1).

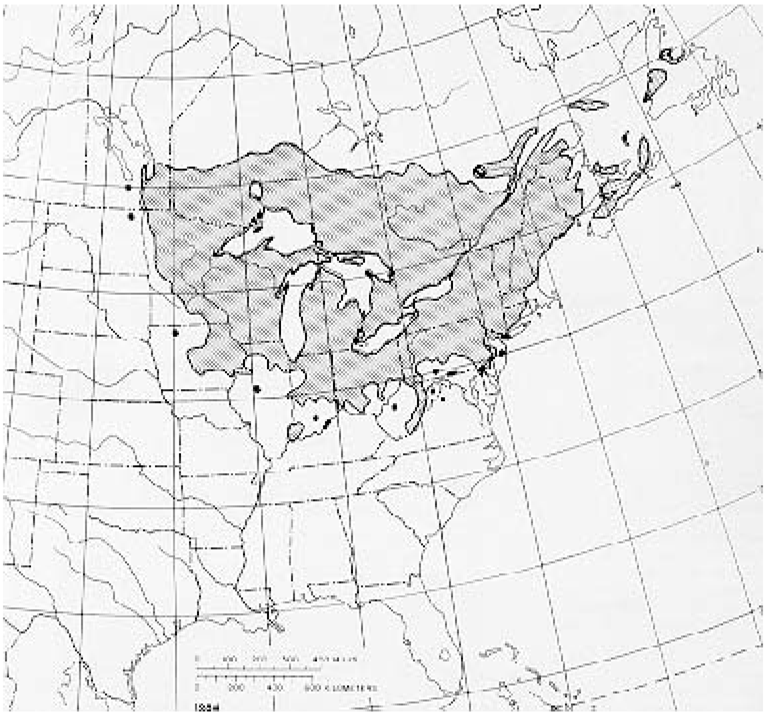

Fig. 1 The native range of Black Ash (Silvics Manual, USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/fraxinus/nigra.htm. June 10, 2006).

Black ash is a small tree. The largest trees reach a height of 60 to 70 ft and a diameter of 12 to 24 in. Black ash favors low-lying areas that are very wet and marshy. This species does not adapt well to dry soil. With a relatively slow growth rate, black ash has a site index range at base age 50 years from 50 to 80 ft in northern Wisconsin and Michigan (Silvics Manual, USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/fraxinus/nigra.htm. June 10, 2006).

The wood is soft but durable and easily split into thin layers, black ash is widely used in making baskets, barrel hoops and chair bottoms. The seeds are an important food source to birds and the twigs and leaves provide browse for deer and moose (What tree is it ?

http://www.inspire.net/trees/fact%20pages/ash_black/ash_black.html. and Silvics

Manual, USDA Forest Service.

http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/fraxinus/nigra.htm. June

10, 2006).

Kurmis and Kim (1989) studied black ash stand composition and structure in Carlton County, Minnesota. The author indicated that black ash is commonly found growing in Association with American elm, and other hardwoods on better drained, nutrient-rich sites, and with balsam fir and northern white-cedar on wetter, less nutrient-rich sites. Shrub species, like mountain maple, red-osier dogwood, winterberry, and beaked hazel, are also commonly found growing with black ash.

Literature cited

Kurmis, V.; J.H. Kim. 1989. Black ash stand composition and structure in Carlton County. Minnesota. Staff Paper Series Number 69. St. Paul, MN: University of Minnesota, College of Forestry. 25 p.

Species ___Black ash________ Region ______Lake States_________________

Site indices 60, 70 and 80 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 3.18, 3.55, and 4.45 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 25 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a “thinning and final harvest” regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183553598 and 0.489476260, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Perala and Alban (1994) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$Y = 0.01424D^{1.512}H^{1.518}*1000$$

where:

Y = component dry-weight (kg.)

D = diameter at breast height (cm.)

H = height (cm.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be \$92/mbf (International 1/4) (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005) and pulpwood price was assumed to be \$16/cord (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005). The price of carbon was assumed to be \$0, \$10, \$37 or \$50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of black ash plantations in the Lake States.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$130.8	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]Data from Gary Kronrad, personal communications, Stephen F. Austin State University, January 27,2006.

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Table 1. Total tons of carbon sequestered per acre for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	14.88	14.80	14.80	14.80	14.80	14.80
70	18.31	18.31	18.31	18.31	18.31	18.31
80	23.70	22.56	22.56	22.14	21.38	21.38

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	14.88	14.80	14.80	14.80	14.80	14.80
70	18.31	18.31	18.31	18.31	18.31	18.31
80	23.28	22.56	22.56	22.56	22.14	22.14

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	14.88	14.81	13.38	13.18	12.73	12.73
70	18.47	18.95	18.95	17.33	15.55	15.55
80	23.65	23.65	22.30	21.72	19.10	18.53

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	14.88	12.93	12.73	12.73	13.18	13.18
70	18.47	18.95	18.02	15.55	15.55	15.55
80	23.65	23.65	22.19	18.54	19.06	19.06

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<48-59-**89**[2]> (30%)[3]	<48-58-**89**>[4] (30%)	<48-58-**89**> (30%)	<48-58-**89**> (30%)	<48-58-**89**> (30%)	<48-58-**89**> (30%)
70	<36-48-**80**> (30%)	<36-48-**80**> (30%)	<36-48-**80**> (30%)	<36-48-**80**> (30%)	<36-48-**80**> (30%)	<36-48-**80**> (30%)
80	<40-46-**82**> (30%)	<40-46-**71**> (30%)	<40-46-**71**> (30%)	<40-45-**71**> (30%)	<33-**75**> (30%)	<33-**75**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<48-59-**89**[2]> (30%)[3]	<48-58-**89**>[4] (30%)	<48-58-**89**> (30%)	<48-58-**89**> (30%)	<48-58-**89**> (30%)	<48-58-**89**> (30%)
70	<36-48-**80**> (30%)	<36-48-**80**> (30%)	<36-48-**80**> (30%)	<36-48-**80**> (30%)	<36-48-**80**> (30%)	<36-48-**80**> (30%)
80	41-77-**86** (30%)	<40-46-**71**> (30%)	<40-46-**71**> (30%)	<40-46-**71**> (30%)	<40-45-**71**> (30%)	<40-45-**71**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	48-59-**89**[2] (30%)[3]	<58-64-**90**>[4] (30%)	<83-**90**> (30%)	<85-**90**> (30%)	**<90>**	**<90>**
70	41-**89** (30%)	61-75-**88** (30%)	<62-79-**89**> (30%)	<71-80-**90**> (20%)	**<90>**	**<90>**
80	56-80-**89** (30%)	56-80-**89** (30%)	<57-**84**> (20%)	<64-**85**> (20%)	<84-**89**> (20%)	**<88>**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	48-59-**89**[2] (30%)[3]	**89**	**<90>**[4]	**<90>**	<85-**90>** (30%)	<85-**90>** (30%)
70	41-**89** (30%)	62-79-**89** (30%)	<61-85-**90>** (20%)	**<90>**	**<90>**	**<90>**
80	56-80-**89** (30%)	56-80-**89** (30%)	64-**89** (20%)	**<89>**	<85-**90>** (20%)	<85-**90>** (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$299.52	-$371.90	-$379.73	-$379.32	-$378.10	-$377.06
70	-$228.52	-$353.89	-$374.06	-$377.17	-$377.19	-$377.19
80	-$175.58	-$340.71	-$370.83	-$376.46	-$376.97	-$376.51

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$177.19	-$292.93	-$327.43	-$343.10	-$351.94	-$357.50
70	-$72.95	-$249.03	-$302.49	-$326.38	-$339.82	-$339.82
80	$33.27	-$201.85	-$273.17	-$305.91	-$324.51	-$336.41

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$153.09	-$78.43	-$184.72	-$244.61	-$281.08	-$304.62
70	$371.86	$43.87	-$103.52	-$186.36	-$237.55	-$237.55
80	$617.37	$191.41	-$2.48	-$112.20	-$181.14	-$227.12

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$312.11	$28.36	-$114.92	-$196.92	-$246.87	-$279.13
70	$589.54	$190.05	-$5.83	-$118.24	-$188.05	-$188.05
80	$904.58	$385.45	$130.28	-$18.09	-$111.83	-$174.40

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$335.92	-$376.65	-$380.29	-$379.39	-$378.10	-$377.06
70	-$264.28	-$360.82	-$375.13	-$377.34	-$377.21	-$377.21
80	-$201.54	-$351.18	-$372.87	-$376.86	-$377.02	-$376.52

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$198.72	-$296.60	-$327.92	-$343.16	-$351.95	-$357.51
70	-$84.37	-$253.91	-$303.36	-$326.53	-$339.84	-$339.84
80	$37.67	-$208.05	-$274.68	-$306.23	-$324.57	-$336.43

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$171.69	-$79.36	-$184.97	-$244.65	-$281.08	-$304.62
70	$417.06	$44.45	-$103.67	-$186.39	-$237.55	-$237.55
80	$692.39	$193.81	-$2.49	-$112.23	-$181.14	-$227.12

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for black ash plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$350.04	$28.72	-$115.08	-$196.95	-$246.87	-$279.13
70	$661.18	$192.43	-$5.84	-$118.26	-$188.05	-$188.05
80	$1,014.51	$390.28	$130.48	-$18.09	-$111.83	-$174.40

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for black ash plantations by soil productivity and real alternative rates of return in the lakes states region). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	48-59-**89**[3] (30%)[4]	642.00	0	565.68	0	1,799.98	3.87	3,007.66	3.87
	5.0%	48-58-**89** (30%)	642.00	0	558.03	0	1,792.41	3.85	2,992.44	3.85
	7.5%	48-58-**89** (30%)	642.00	0	558.03	0	1,792.41	3.85	2,992.44	3.85
	10.0%	48-58-**89** (30%)	642.00	0	558.03	0	1,792.41	3.85	2,992.44	3.85
	12.5%	48-58-**89** (30%)	642.00	0	558.03	0	1,792.41	3.85	2,992.44	3.85
	15.0%	48-58-**89** (30%)	642.00	0	558.03	0	1,792.41	3.85	2,992.44	3.85
70	2.5%	36-48-**80** (30%)	566.49	0	644.33	0	1,676.43	6.62	2,887.25	6.62
	5.0%	36-48-**80** (30%)	566.49	0	644.33	0	1,676.43	6.62	2,887.25	6.62
	7.5%	36-48-**80** (30%)	566.49	0	644.33	0	1,676.43	6.62	2,887.25	6.62
	10.0%	36-48-**80** (30%)	566.49	0	644.33	0	1,676.43	6.62	2,887.25	6.62
	12.5%	36-48-**80** (30%)	566.49	0	644.33	0	1,676.43	6.62	2,887.25	6.62
	15.0%	36-48-**80** (30%)	566.49	0	644.33	0	1,676.43	6.62	2,887.25	6.62
80	2.5%	40-46-**82** (30%)	773.14	0	645.13	0	1,627.35	10.02	3,045.62	10.02
	5.0%	40-46-**71** (30%)	773.14	0	645.13	0	1,977.59	6.49	3,395.86	6.49
	7.5%	40-46-**71** (30%)	773.14	0	645.13	0	1,977.59	6.49	3,395.86	6.49
	10.0%	40-45-**71** (30%)	773.14	0	629.13	0	1,925.78	6.33	3,328.05	6.33
	12.5%	33-**75** (30%)	560.74	0	-[5]	-	2,541.82	7.46	3,102.56	7.46
	15.0%	33-**75** (30%)	560.74	0	-	-	2,541.82	7.46	3,102.56	7.46

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 18. Volume removed from the financially optimal schedules for black ash plantations by soil productivity and real alternative rates of return in the lakes states region. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	48-59-**89**[3] (30%)[4]	642.00	0	565.68	0	1,799.98	3.87	3,007.66	3.87
	5.0%	48-58-**89** (30%)	642.00	0	558.03	0	1,792.41	3.85	2,992.44	3.85
	7.5%	48-58-**89** (30%)	642.00	0	558.03	0	1,792.41	3.85	2,992.44	3.85
	10.0%	48-58-**89** (30%)	642.00	0	558.03	0	1,792.41	3.85	2,992.44	3.85
	12.5%	48-58-**89** (30%)	642.00	0	558.03	0	1,792.41	3.85	2,992.44	3.85
	15.0%	48-58-**89** (30%)	642.00	0	558.03	0	1,792.41	3.85	2,992.44	3.85
70	2.5%	36-48-**80** (30%)	566.49	0	644.33	0	1,676.43	6.62	2,887.25	6.62
	5.0%	36-48-**80** (30%)	566.49	0	644.33	0	1,676.43	6.62	2,887.25	6.62
	7.5%	36-48-**80** (30%)	566.49	0	644.33	0	1,676.43	6.62	2,887.25	6.62
	10.0%	36-48-**80** (30%)	566.49	0	644.33	0	1,676.43	6.62	2,887.25	6.62
	12.5%	36-48-**80** (30%)	566.49	0	644.33	0	1,676.43	6.62	2,887.25	6.62
	15.0%	36-48-**80** (30%)	566.49	0	644.33	0	1,676.43	6.62	2,887.25	6.62
80	2.5%	41-77-**86** (30%)	790.34	0	723.08	2.38	1,435.39	8.84	2,948.81	11.22
	5.0%	40-46-**71** (30%)	773.14	0	645.13	0	1,977.59	6.49	3,395.86	6.49
	7.5%	40-46-**71** (30%)	773.14	0	645.13	0	1,977.59	6.49	3,395.86	6.49
	10.0%	40-46-**71** (30%)	773.14	0	645.13	0	1,977.59	6.49	3,395.86	6.49
	12.5%	40-45-**71** (30%)	773.14	0	629.13	0	1,925.78	6.33	3,328.05	6.33
	15.0%	40-45-**71** (30%)	773.14	0	629.13	0	1,925.78	6.33	3,328.05	6.33

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for black ash plantations by soil productivity and real alternative rates of return in the lakes states region. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	48-59-**89**[3] (30%)[4]	642.00	0	565.68	0	1,799.98	3.87	3,007.66	3.87
	5.0%	58-64-**90** (30%)	736.92	0	564.76	0	1,725.48	3.70	3,027.16	3.70
	7.5%	83-**90** (30%)	1023.69	0	-[5]	-	2,555.76	0	3,579.45	0.00
	10.0%	85-**90** (30%)	1021.80	0	-	-	2,507.61	0	3,529.41	0.00
	12.5%	**90**	-	-	-	-	3,417.10	0	3,417.10	0.00
	15.0%	**90**	-	-	-	-	3,417.10	0	3,417.10	0.00
70	2.5%	41-**89** (30%)	630.44	0	-	-	2,112.07	8.37	2,742.51	8.37
	5.0%	61-75-**88** (30%)	978.46	0	919.56	0	1,506.36	5.95	3,404.38	5.95
	7.5%	62-79-**89** (30%)	980.06	0	948.93	0	1,491.70	5.89	3,420.69	5.89
	10.0%	71-80-**90** (20%)	672.87	0	649.71	0	2,231.67	4.04	3,554.25	4.04
	12.5%	**90**	-	-	-	-	3,903.20	0	3,903.20	0.00
	15.0%	**90**	-	-	-	-	3,903.20	0	3,903.20	0.00
80	2.5%	56-80-**89** (30%)	1102.56	0	700.17	2.30	1,399.46	8.61	3,202.19	10.91
	5.0%	56-80-**89** (30%)	1102.56	0	700.17	2.30	1,399.46	8.61	3,202.19	10.91
	7.5%	57-**84** (20%)	740.33	0	-	-	2,623.67	8.67	3,364.00	8.67
	10.0%	64-**85** (20%)	766.36	0	-	-	2,530.23	8.37	3,296.59	8.37
	12.5%	84-**89** (20%)	848.75	0	-	-	2,186.91	7.27	3,035.66	7.27
	15.0%	**88**	-	-	-	-	2,689.58	8.41	2,689.58	8.41

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for black ash plantations by soil productivity and real alternative rates of return in the lakes states region. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	48-59-**89**[3] (30%)[4]	642.00	0	565.68	0	1,799.98	3.87	3,007.66	3.87
	5.0%	**89**	-[5]	-	-	-	3,463.97	0	3,463.97	0
	7.5%	**90**	-	-	-	-	3,417.10	0	3,417.10	0
	10.0%	**90**	-	-	-	-	3,417.10	0	3,417.10	0
	12.5%	85-**90** (30%)	1021.80	0	-	-	2,507.61	0	3,529.41	0
	15.0%	85-**90** (30%)	1021.80	0	-	-	2,507.61	0	3,529.41	0
70	2.5%	41-**89** (30%)	630.44	0	-	-	2,112.07	8.37	2,742.51	8.37
	5.0%	62-79-**89** (30%)	980.06	0	948.93	0	1,491.70	5.89	3,420.69	5.89
	7.5%	61-85-**90** (20%)	652.26	0	736.92	0	2,321.66	4.10	3,710.84	4.10
	10.0%	**90**	-	-	-	-	3,903.20	0	3,903.20	0
	12.5%	**90**	-	-	-	-	3,903.20	0	3,903.20	0
	15.0%	**90**	-	-	-	-	3,903.20	0	3,903.20	0
80	2.5%	56-80-**89** (30%)	1102.56	0	700.17	2.30	1,399.46	8.61	3,202.19	10.91
	5.0%	56-80-**89** (30%)	1102.56	0	700.17	2.30	1,399.46	8.61	3,202.19	10.91
	7.5%	64-**89** (20%)	766.36	0	-	-	2,621.55	8.77	3,387.91	8.77
	10.0%	**89**	-	-	-	-	2,646.52	8.65	2,646.52	8.65
	12.5%	85-**90** (20%)	848.66	0	-	-	2,184.47	7.28	3,033.13	7.28
	15.0%	85-**90** (20%)	848.66	0	-	-	2,184.47	7.28	3,033.13	7.28

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for black ash plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	60	<48-59-**89**[2]>[3] (30%)[4]	<48-59-**89**> (30%)	0%	48-59-**89** (30%)	0%	48-59-**89** (30%)	0%
	70	<36-48-**80**> (30%)	<36-48-**80**> (30%)	0%	41-**89** (30%)	11%	41-**89** (30%)	11%
	80	<40-46-**82**> (30%)	41-77-**86** (30%)	5%	56-80-**89** (30%)	9%	56-80-**89** (30%)	9%
5.00%	60	<48-58-**89**>[4] (30%)	<48-58-**89**> (30%)	0%	<58-64-**90**> (30%)	1%	**89**	0%
	70	<36-48-**80**> (30%)	<36-48-**80**> (30%)	0%	61-75-**88** (30%)	10%	62-79-**89** (30%)	11%
	80	<40-46-**71**> (30%)	<40-46-**71**> (30%)	0%	56-80-**89** (30%)	25%	56-80-**89** (30%)	25%
7.50%	60	<48-58-**89**> (30%)	<48-58-**89**> (30%)	0%	<83-**90**> (30%)	1%	**<90>**	1%
	70	<36-48-**80**> (30%)	<36-48-**80**> (30%)	0%	<62-79-**89**> (30%)	11%	<61-85-**90**> (20%)	13%
	80	<40-46-**71**> (30%)	<40-46-**71**> (30%)	0%	<57-**84**> (20%)	18%	64-**89** (20%)	25%
10.00%	60	<48-58-**89**> (30%)	<48-58-**89**> (30%)	0%	<85-**90**> (30%)	1%	**<90>**	1%
	70	<36-48-**80**> (30%)	<36-48-**80**> (30%)	0%	<71-80-**90**> (20%)	13%	**<90>**	13%
	80	<40-45-**71**> (30%)	<40-46-**71**> (30%)	0%	<64-**85**> (20%)	20%	**<89>**	25%
12.50%	60	<48-58-**89**> (30%)	<48-58-**89**> (30%)	0%	**<90>**	1%	<85-**90**> (30%)	1%
	70	<36-48-**80**> (30%)	<36-48-**80**> (30%)	0%	**<90>**	13%	**<90>**	13%
	80	<33-**75**> (30%)	<40-45-**71**> (30%)	5%	<84-**89**> (20%)	19%	<85-**90**> (20%)	20%
15.00%	60	<48-58-**89**> (30%)	<48-58-**89**> (30%)	0%	**<90>**	1%	<85-**90**> (30%)	1%
	70	<36-48-**80**> (30%)	<36-48-**80**> (30%)	0%	**<90>**	13%	**<90>**	13%
	80	<33-**75**> (30%)	<40-45-**71**> (30%)	-5%	**<88>**	17%	<85-**90**> (20%)	20%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for black ash plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	60	-335.92	-198.72		171.69		350.04	
	70	-264.28	-84.37		417.06		661.18	
	80	-201.54	37.67		692.39		1,014.51	
5.00%	60	-376.65	-296.60		-79.36		28.72	
	70	-360.82	-253.91		44.45		192.43	
	80	-351.18	-208.05		193.81		390.28	
7.50%	60	-380.29	-327.92		-184.97		-115.08	
	70	-375.13	-303.36		-103.67		-5.84	
	80	-372.87	-274.68		-2.49		130.48	
10.00%	60	-379.39	-343.16		-244.65		-196.95	
	70	-377.34	-326.53		-186.39		-118.26	
	80	-376.86	-306.23		-112.23		-18.09	
12.50%	60	-378.10	-351.95		-281.08		-246.87	
	70	-377.21	-339.84		-237.55		-188.05	
	80	-377.02	-324.57		-181.14		-111.83	
15.00%	60	-377.06	-357.51		-304.62		-279.13	
	70	-377.21	-339.84		-237.55		-188.05	
	80	-376.52	-336.43		-227.12		-174.40	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

Lake States- Black ash - Timber Only Rotations (C = $0/ton)

Black ash, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 59 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 5). This optimal management regime will generate the maximum SEV of -$335.92 (Table 13), with a NPW of -$299.52 per acre (Table 9). This means that -$335.92 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$299.52 per acre for managing one rotation, or -$335.92 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,007.66 cubic feet of pulpwood and 3.87 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 14.88 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Black ash, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 58 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 5). This optimal management regime will generate the maximum SEV of -$376.65 (Table 13), with a NPW of -$371.90 per acre (Table 9). This financially optimal rotation would produce an estimated

2,992.44 cubic feet of pulpwood and 3.85 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 14.80 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 58 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 5). This optimal management regime will generate the maximum SEV of -$380.29 (Table 13), with a NPW of -$379.73 per acre (Table 9). This financially optimal rotation would produce an estimated 2,992.44 cubic feet of pulpwood and 3.85 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 14.80 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 58 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 5). This optimal management regime will generate the maximum SEV of -$379.39 (Table 13), with a NPW of -$379.32 per acre (Table 9). This financially optimal rotation would produce an estimated 2,992.44 cubic feet of pulpwood and 3.85 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 14.80 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 58 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 5). This optimal management regime will generate the maximum SEV of -$378.10 (Table 13), with a NPW of -

$378.10 per acre (Table 9). This financially optimal rotation would produce an estimated 2,992.44 cubic feet of pulpwood and 3.85 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 14.80 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 58 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 5). This optimal management regime will generate the maximum SEV of -$377.06 (Table 13), with a NPW of -$377.06 per acre (Table 9). This financially optimal rotation would produce an estimated 2,992.44 cubic feet of pulpwood and 3.85 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 14.80 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 5). This optimal management regime will generate the maximum SEV of -$264.28 (Table 13), with a NPW of -$228.52 per acre (Table 9). This financially optimal rotation would produce an estimated 2,887.25 cubic feet of pulpwood and 6.62 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 18.31 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80(Table 5). This optimal

management regime will generate the maximum SEV of -$360.82 (Table 13), with a NPW of -$353.89 per acre (Table 9). This financially optimal rotation would produce an estimated 2,887.25 cubic feet of pulpwood and 6.62 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 18.31 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 5). This optimal management regime will generate the maximum SEV of -$375.13 (Table 13), with a NPW of -$374.06 per acre (Table 9). This financially optimal rotation would produce an estimated 2,887.25 cubic feet of pulpwood and 6.62 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 18.31 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 5). This optimal management regime will generate the maximum SEV of -$377.34 (Table 13), with a NPW of -$377.17 per acre (Table 9). This financially optimal rotation would produce an estimated 2,887.25 cubic feet of pulpwood and 6.62 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 18.31 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 48 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 80 (Table 5). This optimal management regime will generate the maximum SEV of -$377.21 (Table 13), with a NPW of -$377.19 per acre (Table 9). This financially optimal rotation would produce an estimated 2,887.25 cubic feet of pulpwood and 6.62 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 18.31 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 5). This optimal management regime will generate the maximum SEV of -$377.21 (Table 13), with a NPW of -$377.19 per acre (Table 9). This financially optimal rotation would produce an estimated 2,887.25 cubic feet of pulpwood and 6.62 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 18.31 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 5). This optimal management regime will generate the maximum SEV of -$201.54 (Table 13), with a NPW of -$175.58 per acre (Table 9). This financially optimal rotation would produce an estimated 3,045.62 cubic feet of pulpwood and 10.02 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.70 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 5). This optimal management regime will generate the maximum SEV of -$351.18 (Table 13), with a NPW of -$340.71 per acre (Table 9). This financially optimal rotation would produce an estimated 3,395.86 cubic feet of pulpwood and 6.49 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.56 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 5). This optimal management regime will generate the maximum SEV of -$372.87 (Table 13), with a NPW of -$370.83 per acre (Table 9). This financially optimal rotation would produce an estimated 3,395.86 cubic feet of pulpwood and 6.49 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.56 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 5). This optimal management regime will generate the maximum SEV of -$376.86 (Table 13), with a NPW of -$376.46 per acre (Table 9). This financially optimal rotation would produce an estimated 3,328.05 cubic feet of pulpwood and 6.33 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.14 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 33 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 5). This optimal management regime will generate the maximum SEV of -$377.02 (Table 13), with a NPW of -$376.97 per acre (Table 9). This financially optimal rotation would produce an estimated 3,102.56 cubic feet of pulpwood and 7.46 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 21.38 net tons of carbon per acre during one rotation (Table 1).

Black ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 33 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 5). This optimal management regime will generate the maximum SEV of -$376.52 (Table 13), with a NPW of -$376.51 per acre (Table 9). This financially optimal rotation would produce an estimated 3,102.56 cubic feet of pulpwood and 7.46 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 21.38 net tons of carbon per acre during one rotation (Table 1).

Lake States- Black ash - Timber Only Rotations (C = $10/ton)

Black ash, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 59 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$198.72 (Table 14), with a NPW of -$177.19 per acre (Table 10). This means that -$198.72 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$177.19 per acre for managing one rotation, or -$198.72 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,007.66 cubic feet of pulpwood and 3.87 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 14.88 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Black ash, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 58 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$296.60 (Table 14), with a NPW of -$292.93 per acre (Table 10). This financially optimal rotation would produce an estimated

2,992.44 cubic feet of pulpwood and 3.85 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 14.80 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 58 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$327.92 (Table 14), with a NPW of -$327.43 per acre (Table 10). This financially optimal rotation would produce an estimated 2,992.44 cubic feet of pulpwood and 3.85 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 14.80 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 58 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$343.16 (Table 14), with a NPW of -$343.10 per acre (Table 10). This financially optimal rotation would produce an estimated 2,992.44 cubic feet of pulpwood and 3.85 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 14.80 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 58 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$351.95 (Table 14), with a NPW of -

$351.94 per acre (Table 10). This financially optimal rotation would produce an estimated 2,992.44 cubic feet of pulpwood and 3.85 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 14.80 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 58 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$357.51 (Table 14), with a NPW of -$357.50 per acre (Table 10). This financially optimal rotation would produce an estimated 2,992.44 cubic feet of pulpwood and 3.85 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 14.80 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 6). This optimal management regime will generate the maximum SEV of -$84.37 (Table 14), with a NPW of -$72.95 per acre (Table 10). This financially optimal rotation would produce an estimated 2,887.25 cubic feet of pulpwood and 6.62 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 18.31 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 6). This optimal

management regime will generate the maximum SEV of -$253.91 (Table 14), with a NPW of -$249.03 per acre (Table 10). This financially optimal rotation would produce an estimated 2,887.25 cubic feet of pulpwood and 6.62 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 18.31 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 6). This optimal management regime will generate the maximum SEV of -$303.36 (Table 14), with a NPW of -$302.49 per acre (Table 10). This financially optimal rotation would produce an estimated 2,887.25 cubic feet of pulpwood and 6.62 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 18.31 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 6). This optimal management regime will generate the maximum SEV of -$326.53 (Table 14), with a NPW of -$326.38 per acre (Table 10). This financially optimal rotation would produce an estimated 2,887.25 cubic feet of pulpwood and 6.62 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 18.31 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 48 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 80 (Table 6). This optimal management regime will generate the maximum SEV of -$339.84 (Table 14), with a NPW of -$339.82 per acre (Table 10). This financially optimal rotation would produce an estimated 2,887.25 cubic feet of pulpwood and 6.62 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 18.31 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 6). This optimal management regime will generate the maximum SEV of -$339.84 (Table 14), with a NPW of -$339.82 per acre (Table 10). This financially optimal rotation would produce an estimated 2,887.25 cubic feet of pulpwood and 6.62 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 18.31 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 77 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 86 (Table 6). This optimal management regime will generate the maximum SEV of $37.67 (Table 14), with a NPW of $33.27 per acre (Table 10). This financially optimal rotation would produce an estimated 2,948.81 cubic feet of pulpwood and 11.22 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.28 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 6). This optimal management regime will generate the maximum SEV of -$208.05 (Table 14), with a NPW of -$201.85 per acre (Table 10). This financially optimal rotation would produce an estimated 3,395.86 cubic feet of pulpwood and 6.49 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.56 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 6). This optimal management regime will generate the maximum SEV of -$274.68 (Table 14), with a NPW of -$273.17 per acre (Table 10). This financially optimal rotation would produce an estimated 3,395.86 cubic feet of pulpwood and 6.49 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.56 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 6). This optimal management regime will generate the maximum SEV of -$306.23 (Table 14), with a NPW of -$305.91 per acre (Table 10). This financially optimal rotation would produce an estimated 3,395.86 cubic feet of pulpwood and 6.49 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.56 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 6). This optimal management regime will generate the maximum SEV of -$324.57 (Table 14), with a NPW of -$324.51 per acre (Table 10). This financially optimal rotation would produce an estimated 3,328.05 cubic feet of pulpwood and 6.33 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.14 net tons of carbon per acre during one rotation (Table 2).

Black ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 6). This optimal management regime will generate the maximum SEV of -$336.43 (Table 14), with a NPW of -$336.41 per acre (Table 10). This financially optimal rotation would produce an estimated 3,328.05 cubic feet of pulpwood and 6.33 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.14 net tons of carbon per acre during one rotation (Table 2).

Lake States-Black ash - Timber Only Rotations (C = $37/ton)

Black ash, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 59 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of $171.69 (Table 15), with a NPW of $153.09 per acre (Table 11). This means that $171.69 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $153.09 per acre for managing one rotation, or $171.69 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,007.66 cubic feet of pulpwood and 3.87 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 14.88 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Black ash, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 64 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$79.36 (Table 15), with a NPW of -$78.43 per acre (Table 11). This financially optimal rotation would produce an estimated

3,027.16 cubic feet of pulpwood and 3.70 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 14.81 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 83 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$184.97 (Table 15), with a NPW of -$184.72 per acre (Table 11). This financially optimal rotation would produce an estimated 3,579.45 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 13.38 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$244.65 (Table 15), with a NPW of -$244.61 per acre (Table 11). This financially optimal rotation would produce an estimated 3,529.41 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 13.38 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$281.08 (Table 15), with a NPW of -$281.08 per acre (Table 11). This financially optimal rotation would produce an estimated

3,417.10 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 12.73 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$304.62 (Table 15), with a NPW of -$304.62 per acre (Table 11). This financially optimal rotation would produce an estimated 3,417.10 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 12.73 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of $417.06 (Table 15), with a NPW of $371.86 per acre (Table 11). This financially optimal rotation would produce an estimated 2,742.51 cubic feet of pulpwood and 8.37 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 18.47 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 61 and 75 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 7). This optimal management regime will generate the maximum SEV of $44.45 (Table 15), with a NPW of $43.87 per acre (Table 11). This financially optimal rotation would produce an estimated

3,404.38 cubic feet of pulpwood and 5.95 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 18.95 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 62 and 79 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of -$103.67 (Table 15), with a NPW of -$103.52 per acre (Table 11). This financially optimal rotation would produce an estimated 3,420.69 cubic feet of pulpwood and 5.89 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 18.95 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 71 and 80 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$186.39 (Table 15), with a NPW of -$186.36 per acre (Table 11). This financially optimal rotation would produce an estimated 3,554.25 cubic feet of pulpwood and 4.04 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 17.33 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$237.55 (Table 15), with a NPW of -$237.55 per acre (Table 11). This financially optimal rotation would produce an estimated

3,903.20 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 15.55 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$237.55 (Table 15), with a NPW of -$237.55 per acre (Table 11). This financially optimal rotation would produce an estimated 3,903.20 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 15.55 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 56 and 80 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of $692.39 (Table 15), with a NPW of $617.37 per acre (Table 11). This financially optimal rotation would produce an estimated 3,202.19 cubic feet of pulpwood and 10.91 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.65 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 56 and 80 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of $193.81 (Table 15), with a NPW of $191.41 per acre (Table 11). This financially optimal rotation would produce an estimated

3,202.19 cubic feet of pulpwood and 10.91 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.65 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 57 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 7). This optimal management regime will generate the maximum SEV of -$2.49 (Table 15), with a NPW of -$2.48 per acre (Table 11). This financially optimal rotation would produce an estimated 3,364.00 cubic feet of pulpwood and 8.67 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 22.30 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 64 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 7). This optimal management regime will generate the maximum SEV of -$112.23 (Table 15), with a NPW of -$112.20 per acre (Table 11). This financially optimal rotation would produce an estimated 3,296.59 cubic feet of pulpwood and 8.37 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 21.72 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 84 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of -$181.14 (Table 15), with a NPW of -$181.14 per acre (Table 11). This financially optimal rotation would produce an estimated 3,035.66 cubic feet of pulpwood and 7.27 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 19.10 net tons of carbon per acre during one rotation (Table 3).

Black ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 88 (Table 7). This optimal management regime will generate the maximum SEV of -$227.12 (Table 15), with a NPW of -$227.12 per acre (Table 11). This financially optimal rotation would produce an estimated 2,689.58 cubic feet of pulpwood and 8.41 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 18.53 net tons of carbon per acre during one rotation (Table 3).

Lake States- Black ash - Timber Only Rotations (C = $50/ton)

Black ash, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 59 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of $350.04 (Table 16), with a NPW of $312.11 per acre (Table 12). This means that $350.04 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $312.11 per acre for managing one rotation, or $350.04 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,007.66 cubic feet of pulpwood and 3.87 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 14.88 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Black ash, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of $28.72 (Table 16), with a NPW of $28.36 per acre (Table 12). This financially optimal rotation would produce an estimated 3,463.97 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 12.93 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$115.08 (Table 16), with a NPW of -$114.92 per acre (Table 12). This financially optimal rotation would produce an estimated 3,417.10 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 12.73 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$196.95 (Table 16), with a NPW of -$196.92 per acre (Table 12). This financially optimal rotation would produce an estimated 3,417.10 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 12.73 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$246.87 (Table 16), with a NPW of -$246.87 per acre (Table 12). This financially optimal rotation would produce an estimated 3,529.41 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 13.18 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$279.13 (Table 16), with a NPW of -$279.13 per acre (Table 12). This financially optimal rotation would produce an estimated 3,529.41 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 13.18 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of $661.18 (Table 16), with a NPW of $589.54 per acre (Table 12). This financially optimal rotation would produce an estimated 2,742.51 cubic feet of pulpwood and 8.37 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 18.47 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 62 and 79 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of $192.43 (Table 16), with a NPW of $190.05 per acre (Table 12). This financially optimal rotation would produce an estimated 3,420.69 cubic feet of pulpwood and 5.89 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 18.95 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 61 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$5.84 (Table 16), with a NPW of -$5.83 per acre (Table 12). This financially optimal rotation would produce an estimated 3,710.84 cubic feet of pulpwood and 4.10 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 18.02 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$118.26 (Table 16), with a NPW of -$118.24 per acre (Table 12). This financially optimal rotation would produce an estimated 3,903.20 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 15.55 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$188.05 (Table 16), with a NPW of -$188.05 per acre (Table 12). This financially optimal rotation would produce an estimated 3,903.20 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 15.55 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$188.05 (Table 16), with a NPW of -$188.05 per acre (Table 12). This financially optimal rotation would produce an estimated 3,903.20 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 15.055 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 56 and 80 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of $1,014.51 (Table 16), with a NPW of $904.58 per acre (Table 12). This financially optimal rotation would produce an estimated 3,202.19 cubic feet of pulpwood and 10.91 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.65 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 56 and 80 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of $390.28 (Table 16), with a NPW of $385.45 per acre (Table 12). This financially optimal rotation would produce an estimated 3,202.19 cubic feet of pulpwood and 10.91 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.65 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 64 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of $130.48 (Table 16), with a NPW of $130.28 per acre (Table 12). This financially optimal rotation would produce an estimated 3,387.91 cubic feet of pulpwood and 8.77 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 22.19 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of -$18.09 (Table 16), with a NPW of -$18.09 per acre (Table 12). This financially optimal rotation would produce an estimated 2,646.52 cubic feet of pulpwood and 8.65 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 18.54 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$111.83 (Table 16), with a NPW of -$111.83 per acre (Table 12). This financially optimal rotation would produce an estimated 3,033.13 cubic feet of pulpwood and 7.28 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 19.06 net tons of carbon per acre during one rotation (Table 4).

Black ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$174.40 (Table 16), with a NPW of -$174.40 per acre (Table 12). This financially optimal rotation would produce an estimated 3,033.13 cubic feet of pulpwood and 7.28 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 19.06 net tons of carbon per acre during one rotation (Table 4).

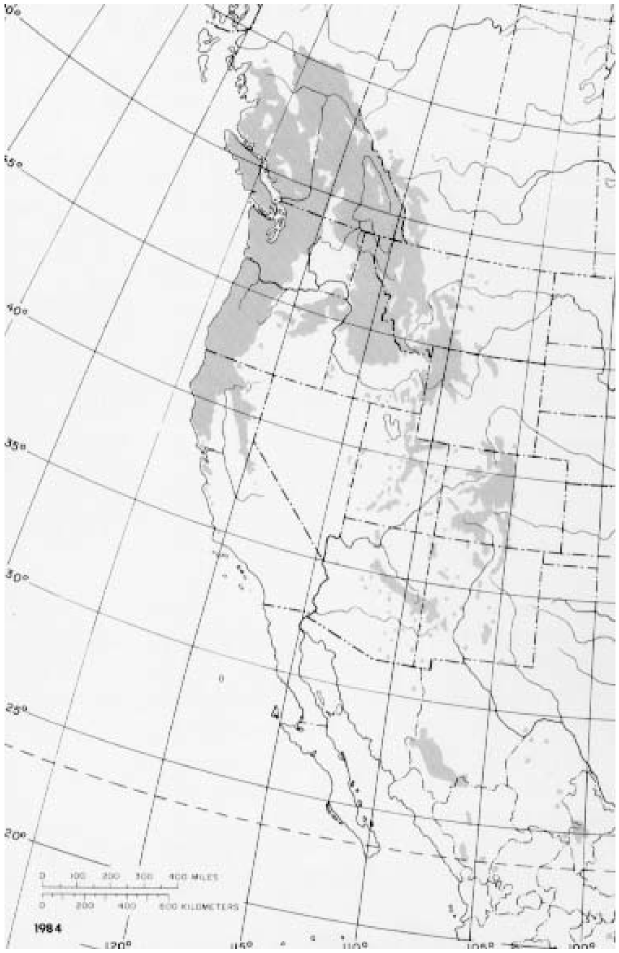
Douglas-Fir *(Pseudotsuga menzieii)*

Biological Information

Douglas-fir is one of the world's most important and valuable timber trees and has been a major component of the forests of western North America since the mid-Pleistocene. Douglas-fir is also referred as red-fir, Oregon-pine, Douglas-spruce, and piño Oregon (Spanish). The species has been successfully introduced in the last 100 years into many regions of the temperate forest zone. Two varieties of the species are recognized: coast Douglas-fir, *P. menziesii* (Mirb.) Franco var. *menziesii,* and Rocky Mountain or blue Douglas-fir, *P. menziesii* var. *glauca* (Beissn.) Franco (Burns and Honkala 1990).

Native Range

The latitudinal range (from 19^{o} to 55^{o} N) of Douglas-fir is the greatest of any commercial conifer of western North America. Its native range resembles an inverted V with uneven sides. From the apex in central British Columbia, the shorter arm extends south along the Pacific Coast Ranges for about 2200 km (1,367 mi) and represents the range of the typical coastal or green variety, *menziesii*; the longer arm stretches along the Rocky Mountains into the mountains of central Mexico over a distance of almost 4500 km (2,769 mi) and represents the range of the other variety, *glauca*- Rocky Mountain or blue (Burns and Honkala 1990).



The native range of Douglas-fir.

Growth and Yield

Natural stands of coastal Douglas-fir normally start with more than 2,500 trees per hectare (1,000/acre); plantations generally have between 750 and 1,500/ha (300 and 600/acre). During the first 5 years, annual height increment is relatively slow but it starts to accelerate after that. Coastal Douglas-fir reaches the largest height increments between ages 20 and 30 and maintains a fairly rapid rate of height growth over a long period. In high-elevation forests of the Oregon-Washington Cascade Range, Douglas-fir has the ability to continue height growth at a substantial rate for more than 200 years.

Depending on site productivity and condition, height growth of Douglas-fir varies. At mid-site indices, height growth of Douglas-fir on dry sites in the Cascade Range of western Oregon is similar to that of upper-slope Douglas-fir in the Washington and Oregon Cascade Range. At higher site indices, however, height growth on dry sites is initially faster but slower later in life. At lower site indices, it is initially slower but faster later in life. Coastal Douglas-fir is very long lived; ages in excess of 500 years are not uncommon and some have exceeded 1,000 years (Burns and Honkala 1990).

Due to limited information about yields of coastal Douglas-fir under intensive management for an entire rotation, it is necessary to rely on estimates based on growth models, yields from unmanaged stands, or intensively managed stands in regions where Douglas-fir has been introduced as an exotic. Productivity difference between the best and poorest sites is more than 250 percent if measured in cubic volume of wood produced. Depending on site quality, mean annual net increments at age 50 vary from 3.7 to 13.4 m^3/ha (53 to 191 ft^3/acre) in unmanaged stands. Estimates of gross yields may increase these values as much as 80 percent, depending on mensurational techniques and assumptions. Comparisons of gross yields from unmanaged stands with those from managed stands of the same site indexes in Europe and New Zealand suggest that yields in managed stands will be considerably higher than would be indicated by estimates based on yields in unmanaged stands. Managed stands of coastal Douglas-fir can presumably produce mean annual increments of 7 m^3/ha (100 ft^3/acre) on poor sites and exceed 28 m^3/ha (400 ft^3/acre) on the highest sites under rotations between 50 and 80 years. Although information on productivity of Douglas-fir in terms of total biomass production is still limited, indications are that it may reach 1000 t/ha (447 tons/acre) on high sites (Burns and Honkala 1990).

The interior variety of Douglas-fir does not attain the growth rates, dimensions, or age of the coastal variety. On low sites, growth is sometimes so slow that trees do not reach saw-log size before old age and decadence overtake them. Interior Douglas-fir reaches an average height of 30 to 37 m (100 to 120 ft) with a d.b.h. between 38 and 102 cm (15 and 40 in) in 200 to 300 years. On the best sites, dominant trees may attain a height of 49 m (160 ft) and a d.b.h. of 152 cm (60 in). Diameter growth becomes extremely slow and height growth practically ceases after age 200. Interior Douglas-fir, however, appears capable of response to release by accelerated diameter growth at any size or age. The interior variety is not as long lived as the coastal variety and rarely lives more than 400 years (Burns and Honkala 1990).

Gross volume yields for Douglas-fir east of the Cascades in Oregon and Washington range from 311 m^3/ha (4,442 ft^3/acre) for site index 15.2 m or 50 ft (at age 50) to 1523 m^3/ha (21,759 ft^3/acre) for site index 33.5 m (110 ft). In the northern Rocky Mountains, estimates of yield capabilities of habitat types where Douglas-fir is climax range from about 1.4 to 7 m^3/ha (20 to 100 ft^3/acre) per year to more than 9.8 m^3/ha (140 ft^3/acre) per year in some of the more moist habitat types where Douglas-fir is seral (Burns and Honkala 1990).

Limited information is available on yields of Douglas-fir in the southern Rocky Mountain region. In New Mexico, a virgin stand of Douglas-fir (61 percent) and associated species averaged 182 m^3/ha (13,000 fbm/acre). Occasionally, stands yield as high as 840 m^3/ha (60,000 fbm/acre). Annual growth rates from 2.0 to 3.9 m^3/ha (140 to

280 fbm/acre) after partial cutting have been reported in New Mexico (Burns and Honkala 1990).

Special Uses

Douglas-fir is grown as a Christmas tree on rotations ranging from 4 to 7 years, and trees are sheared each year to obtain a pyramid-shaped crown. Attempts to grow Douglas-fir as a Christmas tree in North America outside its native range have not been successful Coastal Douglas-fir is usually killed by frost, and the interior variety suffers too much from the needle cast disease *Phaeocryptopus gaeumanni* (Burns and Honkala 1990).

Economic Background

The Douglas-fir region is the most biologically productive commercial softwood region in the United States and home to the largest accumulated volumes of commercial sawtimber in the nation. According to the Forest Service assessment of U.S. forest resources, approximately 55% of Pacific Northwest Douglas-fir and Hemlock-Sitka spruce forestlands, the two dominant conifer forest types in the region by land area and commercial significance, are capable of generating more than 120 cubic feet annual growth per acre (Prudham 2005). This represents the highest rated productivity class used in the inventory, and nearly 70 percent of Douglas-fir forestland owned by the forest industry in the Pacific Northwest is rated in this highest productivity class (Prudham 2005).

Interior Douglas-fir provides a wide variety of primary products including lumber, plywood, pulp and paper, particleboard and fiberboard, house logs, posts and poles and fuelwood. Interior Douglas-fir is extremely important to the Inland region of the United States, primarily in Idaho, Montana, Oregon and Washington (Keegan 1991). The annual value of primary products manufactured from interior Douglas-fir is over $1 billion. The direct employment associated with harvesting and processing Douglas-fir is estimated at 11,000-12,000 workers earning an annual labor income of $300 million. This direct employment also accounts for an additional 20,000-30,000 workers in derivative sectors (Keegan 1991).

White (1993) demonstrated how dynamic programming can be used to determine forest management regimes which will generate the maximum financial returns from a stand of coastal Douglas-fir. The optimal management regime includes initial planting density, the timing and intensity of precommercial thinning, fertilization timing, and the optimal rotation length for a stand of coastal Douglas-fir. Tree and Stand Simulator (TASS), a single-tree, distance-dependent simulator and a crown stand model, simulates the development of the crown and the bole of individual trees. Based on TASS and costs and revenues which reflected 1985 conditions in coastal British Columbia, the results indicate that planting a stand of Douglas-fir on bare land did not generate a positive return when the discount rate was greater than 3%. However, positive returns of forest management could be obtained by assuming real price increases of 2% annually, fixed management costs, low discount rate, or increased future volume for mature timber. White (1993) concluded that earlier thinnings lead to greater revenues at harvest time than the same intensity of thinning at a later date regardless of initial density. Thinning later is more expensive in pure dollar terms and has less growth impact than earlier thinnings but later thinnings become the preferred alternatives in terms of Net Present Value (NPV) and Soil Expectation Value (SEV) when discounting is taken into effect. The optimal intensity of thinning also varied depending on initial density and whether harvest revenue or financial return is optimized. When initial density was 1100 trees per hectare, the optimum financial return was achieved at a lower thinning intensity (200 trees removed per hectare). When initial density was 550 trees per hectare, the optimum financial return was achieved at a lower intensity (175 trees removed per hectare).

Grade-specific price projections used in evaluating management practices which will affect sawlogs quality under various management regimes were developed for Douglas-fir, coast hem-fir, inland hem-fir and ponderosa pine lumber (Haynes and Flight 1992). The price projections provide a basis on which to value changes in wood quality when estimating expected returns. Their results support the notion that increasing scarcity of high-quality material will result in higher prices. Furthermore, Haynes and Fight (2004) used the grade-specific price projections developed to demonstrate the returns to land management of practices producing high-quality logs and help forest managers and owners determine if there is an opportunity to manage for higher-quality timber sold at higher prices. Again, the results support the thought that increasing scarcity of high-quality material will result in higher lumber prices and allow lumber producers to pay higher prices for logs. As a result, these higher prices provide an incentive for stumpage owners and agency land managers to modify management regimes to produce higher quality logs.

Chang (1998) developed a generalization of the classic Faustmann formula for land expectation value (LEV). The generalized Faustmann formula allows the harvest age to vary from timber crop to timber crop by letting the stumpage price, timber yield, regeneration cost, and interest rate vary from timber crop to timber crop. The results indicate that for the Douglas-fir stand, using a 6% interest rate, the harvest age determined by the classic Faustmann formula is 50 years, and the Faustmann LEV is $1,110.84/acre. However, under the generalized Faustmann model, with LEV between $4,876.73 and $3,655.38, the optimal harvest age should be 48 years; with LEV between $3655.38 and $2346.50, the optimal harvest age should be 49 years, and with LEV between $2,346.50 and $976.30, the optimal harvest age should be 50 years.

Knowe (1994) integrated three models to compare yield and net present value of vegetation management in Douglas-fir for nine combinations of site index and planting density. The three models were Regional Vegetation Management Model (RVMM) developed for growth and yield of young Douglas-fir plantations to predict effects of hardwood competition in 20-year-old plantations, ORGANON used to simulate tree growth and silvicultural treatments between ages 20 and 60, and ORGECON used to evaluate the economic consequences of hardwood competition. The objectives of this study are to demonstrate how the RVMM can be used to assess the effects of site productivity, planting density and hardwood competition in stands at age 20 in the Pacific Northwest and to compare the economic benefits of competition control for various levels of site index and planting density.

Briggs and Fight (1992) describe two models, TREEVAL2 and FIP, which aid in synthesizing the effects of wood quality, product value, processing costs, logging costs and management costs on the financial performance of silvicultural regimes and provide a new tool for implementing the systems approach for evaluating coast Douglas-fir regimes. These models use important wood quality attributes that silviculturists can manipulate and provide a means for them to project how silvicultural activities will affect product value and overall financial performance.

Marshall (1991) used planting density and spacing decision for several combination of productivity (site indices of 25 and 40 m at 50 years breast height age) and interest rates (4%, 6% and 8%) for coastal Douglas-fir to illustrate a decision analytic approach to assessing stand-level silvicultural decisions. The planting density options examined were 500, 750, 1100 and 2500 seedlings per hectare. The spacing decisions analyzed were spacing to 1100 or 500 stems per hectare and not spacing at all at a base age of 15 years assuming a density of 2500 stems per hectare at establishment. Results indicate that planting density of 500 seedlings per hectare yields the highest present net worth for all models under all conditions.

Eng et al. (1990) developed management guidelines for economically efficient early stand treatments which would maximize financial returns over the rotation for coast Douglas-fir in southwest Oregon. Short rotations and low stand densities generated the highest financial returns in all site classes. Conducting precommercial thinning to a low stand density was more profitable than planting at low density. Applying fertilization as soon as possible showed to be profitable.

Duke et al. (1989) performed economic analysis to examine economic comparisons of various intensive silvicultural treatments on Douglas-fir stand at Shawnigan Lake, British Columbia. Based on standard investment decision criteria (net present worth, soil expectation value, benefit cost ratio, and internal rate of return), the economics of various intensive silvicultural treatments were compared. The results indicate that investing in any type of silvicultural treatment on a poor site only makes sense if prices are expected to increase and basic silvicultural investments are considered as a harvest cost. Results also indicate that heavier thinnings produce better economic results than light or no thinning, and combinations of fertilization and thinning produce better economic results than only thinning.

Flight et al. (1987) evaluated pruning of coast Douglas-fir using product recovery information for pruned or unpruned logs for both sawn and peeled products. Results indicate that pruning at the earlier age always gave a higher return, and a 5-year difference in the time of pruning can make a significant difference in the financial returns. Depending on the site, the interest rate, and if the stand is fertilized, the number of years between pruning and harvest that gives the highest return from pruning varies. At a 4% interest rate, conducting the harvest 40-50 years after pruning generated the highest return. However, at an 8% interest rate, conducting the harvest 30-40 years after pruning generated the highest return.

Adams (1967) identified the factors which affect production rates of commercial thinning and provided a basis to estimate logging costs over a wide range of situations. Equations were developed to express time study results in terms of 1) log and tree volume in cubic feet and board feet, 2) several stand variables and 3) alternative types of logging equipment. Direct costs of logging by log size were estimated by applying labor costs and machine rates to the times per unit of production. Direct logging costs were then combined with overhead, road construction, and other fixed costs to estimate total logging costs.

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Species <u>   Douglas-fir   </u>   Region <u>Inland California, Southern Cascades</u>

Site indices 100, 110 and 120 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 4.5-in. inside bark top diameter for trees with a minimum of 7 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 9-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 15 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.187943262 and 0.709219858, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Grier and Logan (1977) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Y = \exp(-2.656 + 2.530 \ln X)$$

where:

Y = component dry weight (kg)

X = stem diameter at breast height (cm)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.6% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $331/mbf (Scribner) (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices) and pulpwood price was assumed to be $0/cord (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of Douglas-fir plantations in the Southern Cascades of Inland California.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$80.28	Only once	Year 0	
Seedlings[b] (600 seedlings/ac)	$162	Only Once	Year 0	
Burning[a]	$21.24	Every 5 years	Year 10	Final Harvest
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al (2005).

[b]The seedling cost was estimated based on the seedling prices from Source of Oregon Native Forest Tree Seedlings 2004-2005 by elevation (http://egov.oregon.gov/ODF/PRIVATE_FORESTS/docs/2004Catalog.pdf. February 12, 2006).

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Table 1. Total tons of carbon sequestered per acre for Douglas fir plantations in California by site index and real alternative rates of return. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	103.44	56.05	46.80	46.80	46.80	46.80
110	102.68	52.83	47.80	47.80	47.80	45.23
120	105.09	57.07	49.18	46.40	46.40	46.40

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for Douglas fir plantations in California by site index and real alternative rates of return. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	103.44	58.28	46.80	46.80	46.80	46.80
110	102.68	52.83	52.83	47.80	47.80	45.23
120	105.09	57.07	49.18	46.40	46.40	46.40

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for Douglas fir plantations in California by site index and real alternative rates of return. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	103.44	58.28	46.80	46.80	46.80	46.80
110	102.68	57.73	52.83	47.80	47.80	47.80
120	109.89	57.07	57.07	46.40	46.40	46.40

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for Douglas fir plantations in California by site index and real alternative rates of return. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	103.44	58.28	56.05	46.80	46.80	46.80
110	102.68	60.24	52.83	47.80	47.80	47.80
120	106.89	57.07	57.07	49.18	46.40	46.40

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in California. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	26-32-**45**[2] (25%)[3]	**25**	**21**	**21**	**21**	**21**
110	25-30-**42** (25%)	**22**	**20**	**20**	**20**	**19**
120	25-31-**40** (25%)	**22**	**19**	**18**	**18**	**18**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in California. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	26-32-**45**[2] (25%)[3]	**26**	**21**	**21**	**21**	**21**
110	25-30-**42** (25%)	**22**	**22**	**20**	**20**	**19**
120	25-31-**40** (25%)	**22**	**19**	**18**	**18**	**18**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in California. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	26-32-**45**[2] (25%)[3]	**26**	**21**	**21**	**21**	**21**
110	25-30-**42** (25%)	**22**	**22**	**20**	**20**	**20**
120	25-30-**42** (25%)	**22**	**22**	**18**	**18**	**18**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in California. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	26-32-**45**[2] (25%)[3]	**26**	**25**	**21**	**21**	**21**
110	25-30-**42** (25%)	19-**24** (20%)	**22**	**20**	**20**	**20**
120	25-30-**42** (25%)	**22**	**22**	**19**	**18**	**18**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in California. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$9,975.86	$3,514.04	$1,750.00	$921.19	$419.55	$112.63
110	$10,782.69	$3,837.56	$2,048.10	$1,140.79	$578.78	$233.94
120	$11,668.09	$4,365.15	$2,323.12	$1,356.45	$768.55	$383.66

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in California. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$10,707.01	$3,946.23	$1,994.24	$1,117.63	$578.16	$241.35
110	$11,527.59	$4,186.15	$2,398.86	$1,352.76	$752.25	$372.19
120	$12,448.54	$4,750.78	$2,602.68	$1,577.99	$953.20	$538.15

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in California. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$12,681.13	$5,413.58	$2,653.68	$1,648.03	$1,006.42	$588.88
110	$13,538.82	$5,374.77	$3,157.80	$1,925.09	$1,220.60	$754.69
120	$14,965.52	$5,791.98	$3,594.34	$2,176.16	$1,451.76	$955.27

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in California. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$13,631.63	$4,936.69	$3,163.12	$1,903.41	$1,212.62	$756.21
110	$14,507.19	$5,868.93	$3,523.22	$2,200.66	$1,446.11	$940.09
120	$16,013.00	$6,293.29	$4,002.68	$2,510.90	$1,691.81	$1,156.11

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in California. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$14,695.14	$4,889.04	$2,197.69	$1,050.20	$453.53	$118.09
110	$16,483.24	$5,690.09	$2,622.38	$1,319.03	$632.06	$249.16
120	$18,327.24	$6,472.36	$3,038.39	$1,621.59	$860.33	$412.66

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in California. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$20,080.34	$6,742.71	$3,732.46	$2,169.98	$1,310.84	$792.84
110	$22,176.79	$8,328.30	$4,346.96	$2,544.49	$1,579.23	$992.84
120	$24,476.68	$9,331.29	$4,938.52	$2,949.29	$1,893.85	$1,243.49

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in California. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	18,680.19	7,394.07	3,332.56	1,878.84	1,087.94	617.40
110	20,696.46	7,627.06	3,896.11	2,225.87	1,332.97	797.04
120	22,877.42	8,587.97	4,434.71	2,601.53	1,625.14	1,027.47

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in California. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	20,080.34	6,742.71	3,732.46	2,169.98	1,310.84	792.84
110	22,176.79	8,328.30	4,346.96	2,544.49	1,579.23	992.84
120	24,478.68	9,331.29	4,938.52	2,949.29	1,893.85	1,243.49

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in California. (carbon value = $0/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final Harvest MBF	Total Volume MBF
100	2.50%	26-32-**45**[3] (25%)[4]	10.91	12.04	64.96	87.91
	5.00%	**25**	-[5]	-	42.93	42.92
	7.50%	**21**	-	-	32.14	32.13
	10.00%	**21**	-	-	32.14	32.13
	12.50%	**21**	-	-	32.14	32.13
	15.00%	**21**	-	-	32.14	32.13
110	2.50%	25-30-**42** (25%)	11.24	11.69	66.31	89.24
	5.00%	**22**	-	-	40.28	40.28
	7.50%	**20**	-	-	34.04	34.04
	10.00%	**20**	-	-	34.04	34.04
	12.50%	**20**	-	-	34.04	34.04
	15.00%	**19**	-	-	29.88	29.88
120	2.50%	25-31-**40** (25%)	12.53	12.99	67.89	93.4
	5.00%	**22**	-	-	45.24	45.23
	7.50%	**19**	-	-	35.14	35.13
	10.00%	**18**	-	-	32.04	32.03
	12.50%	**18**	-	-	32.04	32.03

	15.00%	**18**	-	-	32.04	32.03

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 18. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in California. (carbon value = $10/ton)

			1st thinning	2nd thinning	Final Harvest	Total Volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
100	2.50%	26-32-**45**[3] (25%)[4]	10.91	12.04	64.96	87.91
	5.00%	**26**	-[5]	-	45.73	45.72
	7.50%	**21**	-	-	32.14	32.13
	10.00%	**21**	-	-	32.14	32.13
	12.50%	**21**	-	-	32.14	32.13
	15.00%	**21**	-	-	32.14	32.13
110	2.50%	25-30-**42** (25%)	11.24	11.69	66.31	89.24
	5.00%	**22**	-	-	40.28	40.28
	7.50%	**22**	-	-	40.28	40.28
	10.00%	**20**	-	-	34.04	34.04
	12.50%	**20**	-	-	34.04	34.04
	15.00%	**19**	-	-	29.88	29.88
120	2.50%	25-31-**40** (25%)	12.53	12.99	67.89	93.4
	5.00%	**22**	-	-	45.24	45.23
	7.50%	**19**	-	-	35.14	35.13
	10.00%	**18**	-	-	32.04	32.03

	12.50%	**18**	-	-	32.04	32.03
	15.00%	**18**	-	-	32.04	32.03

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in California. (carbon value = $37/ton)

			1st thinning	2nd thinning	Final Harvest	Total Volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
100	2.50%	26-32-**45**[3] (25%)[4]	10.91	12.04	64.96	87.91
	5.00%	**26**	-[5]	-	45.73	45.72
	7.50%	**21**	-	-	32.14	32.13
	10.00%	**21**	-	-	32.14	32.13
	12.50%	**21**	-	-	32.14	32.13
	15.00%	**21**	-	-	32.14	32.13
110	2.50%	25-30-**42** (25%)	11.24	11.69	66.31	89.24
	5.00%	**24**	-	-	45.75	45.74
	7.50%	**22**	-	-	40.28	40.28
	10.00%	**20**	-	-	34.04	34.04
	12.50%	**20**	-	-	34.04	34.04
	15.00%	**20**	-	-	34.04	34.04

120	2.50%	25-30-**42** (25%)	12.53	12.60	73.93	99.05
	5.00%	**22**	-	-	45.24	45.23
	7.50%	**22**	-	-	45.24	45.23
	10.00%	**18**	-	-	32.04	32.03
	12.50%	**18**	-	-	32.04	32.03
	15.00%	**18**	-	-	32.04	32.03

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in California. (carbon value = $50/ton)

			1st thinning	2nd thinning	Final Harvest	Total Volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
100	2.50%	26-32-**45[3] (25%)[4]**	10.91	12.04	64.96	87.91
	5.00%	**26**	-[5]	-	45.73	45.72
	7.50%	**25**	-	-	42.93	42.92
	10.00%	**21**	-	-	32.14	32.13
	12.50%	**21**	-	-	32.14	32.13
	15.00%	**21**	-	-	32.14	32.13
110	2.50%	25-30-**42** (25%)	11.24	11.69	66.31	89.24
	5.00%	19-**24** (20%)	35.16	0	41.12	44.63

	7.50%	**22**	-	-	40.28	40.28
	10.00%	**20**	-	-	34.04	34.04
	12.50%	**20**	-	-	34.04	34.04
	15.00%	**20**	-	-	34.04	34.04
120	2.50%	25-30-**42** (25%)	12.53	12.60	73.93	99.05
	5.00%	**22**	-	-	45.24	45.23
	7.50%	**22**	-	-	45.24	45.23
	10.00%	**19**	-	-	35.14	35.13
	12.50%	**18**	-	-	32.04	32.03
	15.00%	**18**	-	-	32.04	32.03

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for Douglas fir plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	100	26-32-**45**[2] (25%)[3]	26-32-**45** (25%)	0%	26-32-**45** (25%)	0%	26-32-**45** (25%)	0%
	110	25-30-**42** (25%)	25-30-**42** (25%)	0%	25-30-**42** (25%)	0%	25-30-**42** (25%)	0%
	120	25-31-**40** (25%)	25-31-**40** (25%)	0%	25-30-**42** (25%)	5%	25-30-**42** (25%)	5%
5.00%	100	**25**	**26**	4%	**26**	4%	**26**	4%
	110	**22**	**22**	0%	**22**	0%	19-**24** (20%)	9%
	120	**22**	**22**	0%	**22**	0%	**22**	0%
7.50%	100	**21**	**21**	0%	**21**	0%	**25**	19%
	110	**20**	**22**	10%	**22**	10%	**22**	10%
	120	**19**	**19**	0%	**22**	16%	**22**	16%
10.00%	100	**21**	**21**	0%	**21**	0%	**21**	0%
	110	**20**	**20**	0%	**20**	0%	**20**	0%
	120	**18**	**18**	0%	**18**	0%	**19**	6%
12.50%	100	**21**	**21**	0%	**21**	0%	**21**	0%
	110	**20**	**20**	0%	**20**	0%	**20**	0%
	120	**18**	**18**	0%	**18**	0%	**18**	0%
15.00%	100	**21**	**21**	0%	**21**	0%	**21**	0%
	110	**19**	**19**	0%	**20**	5%	**20**	5%
	120	**18**	**18**	0%	**18**	0%	**18**	0%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3] Number in parentheses indicates the percentage of basal area removed during thinning

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for Douglas fir plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	100	14,695.14	20,080.34	37%	18,680.19	27%	20,080.34	37%
	110	16,483.24	22,176.79	35%	20,696.46	26%	22,176.79	35%
	120	18,327.24	24,476.68	34%	22,877.42	25%	24,478.68	34%
5.00%	100	4,889.04	6,742.71	38%	7,394.07	51%	6,742.71	38%
	110	5,690.09	8,328.30	46%	7,627.06	34%	8,328.30	46%
	120	6,472.36	9,331.29	44%	8,587.97	33%	9,331.29	44%
7.50%	100	2,197.69	3,732.46	70%	3,332.56	52%	3,732.46	70%
	110	2,622.38	4,346.96	66%	3,896.11	49%	4,346.96	66%
	120	3,038.39	4,938.52	63%	4,434.71	46%	4,938.52	63%
10.00%	100	1,050.20	2,169.98	107%	1,878.84	79%	2,169.98	107%
	110	1,319.03	2,544.49	93%	2,225.87	69%	2,544.49	93%
	120	1,621.59	2,949.29	82%	2,601.53	60%	2,949.29	82%
12.50%	100	453.53	1,310.84	189%	1,087.94	140%	1,310.84	189%
	110	632.06	1,579.23	150%	1,332.97	111%	1,579.23	150%
	120	860.33	1,893.85	120%	1,625.14	89%	1,893.85	120%
15.00%	100	118.09	792.84	571%	617.40	423%	792.84	571%
	110	249.16	992.84	298%	797.04	220%	992.84	298%
	120	412.66	1,243.49	201%	1,027.47	149%	1,243.49	201%

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>California- Douglas-fir - Timber Only Rotations (C = $0/ton)</u>

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 32 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 45 (Table 5). This optimal management regime will generate the maximum SEV of $14,695.14 (Table 13), with a NPW of $9,975.86 per acre (Table 9). This means that $14,695.14 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $9,975.86 per acre for managing one rotation, or $14,695.14 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 87.91 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 103.44 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 5). This optimal management regime will generate the maximum SEV of $4,889.04 (Table 13), with a NPW of $3,514.04 per acre (Table 9). This financially optimal rotation would

produce an estimated 42.92 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 56.05 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 5). This optimal management regime will generate the maximum SEV of $2,197.69 (Table 13), with a NPW of $1,750.00 per acre (Table 9). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 46.80 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 5). This optimal management regime will generate the maximum SEV of $1,050.20 (Table 13), with a NPW of $921.19 per acre (Table 9). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 46.80 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 5). This optimal management regime will generate the maximum SEV of $453.53 (Table 13), with a NPW of $419.55 per acre (Table 9). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 46.80 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 5). This optimal management regime will generate the maximum SEV of $118.09 (Table 13), with a NPW of $112.63 per acre (Table 9). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 46.80 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 30 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 42 (Table 5). This optimal management regime will generate the maximum SEV of $16,483.24 (Table 13), with a NPW of $10,782.69 per acre (Table 9). This financially optimal rotation would produce an estimated 89.24 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 102.68 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 5). This optimal management regime will generate the maximum SEV of $5,690.09 (Table 13), with a NPW of $3,837.56 per acre (Table 9). This financially optimal rotation would produce an estimated 40.28 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 52.83 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 5). This optimal management regime will generate the maximum SEV of $2,622.38 (Table 13), with a NPW of $2,048.10 per acre (Table 9). This financially optimal rotation would produce an estimated 34.04 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 47.80 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 5). This optimal management regime will generate the maximum SEV of $1,319.03 (Table 13), with a NPW of $1,140.79 per acre (Table 9). This financially optimal rotation would produce an estimated 34.04 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 47.80 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 5). This optimal management regime will generate the maximum SEV of $632.06 (Table 13), with a NPW of $578.78 per acre (Table 9). This financially optimal rotation would produce an estimated 34.04 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 47.80 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 5). This optimal management regime will generate the maximum SEV of $249.16 (Table 13), with a NPW of $233.94 per acre (Table 9). This financially optimal rotation would produce an estimated 29.88 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 45.23 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 31 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 40 (Table 5). This optimal management regime will generate the maximum SEV of $18,327.24 (Table 13), with a NPW of $11,668.09 per acre (Table 9). This financially optimal rotation would produce an estimated 93.40 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 105.09 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 5). This optimal management regime will generate the maximum SEV of $6,472.36 (Table 13), with a NPW of $4,365.15 per acre (Table 9). This financially optimal rotation would produce an estimated 45.23 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 57.07 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 5). This optimal management regime will generate the maximum SEV of $3,038.39 (Table 13), with a NPW of $2,323.12 per acre (Table 9). This financially optimal rotation would produce an estimated 35.13 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 49.18 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 5). This optimal management regime will generate the maximum SEV of $1,621.59 (Table 13), with a NPW of $1,356.45 per acre (Table 9). This financially optimal rotation would produce an estimated 32.03 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 46.40 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 5). This optimal management regime will generate the maximum SEV of $860.33 (Table 13), with a NPW of $768.55 per acre (Table 9). This financially optimal rotation would produce an estimated 32.03 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 46.40 net tons of carbon per acre during one rotation (Table 1).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 5). This

optimal management regime will generate the maximum SEV of $412.66 (Table 13), with a NPW of $383.66 per acre (Table 9). This financially optimal rotation would produce an estimated 32.03 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 46.40 net tons of carbon per acre during one rotation (Table 1).

<u>California- Douglas-fir - Timber Only Rotations (C = $10/ton)</u>

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 32 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 45 (Table 6). This optimal management regime will generate the maximum SEV of $20,080.34 (Table 14), with a NPW of $10,707.01 per acre (Table 10). This means that $20,080.34 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $10,707.01 per acre for managing one rotation, or $20,080.34 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 87.91 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 103.44 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 26 (Table 6). This optimal management regime will generate the maximum SEV of $6,742.71 (Table 14), with a NPW of $3,946.23 per acre (Table 10). This financially optimal rotation would produce an estimated 45.72 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 58.28 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 6). This optimal management regime will generate the maximum SEV of $3,732.46 (Table 14), with a NPW of $1,994.24 per acre (Table 10). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 46.80 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 6). This optimal management regime will generate the maximum SEV of $2,169.98 (Table 14), with a NPW of $1,117.63 per acre (Table 10). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 46.80 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 6). This

optimal management regime will generate the maximum SEV of $1,310.84 (Table 14), with a NPW of $578.16 per acre (Table 10). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 46.80 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 6). This optimal management regime will generate the maximum SEV of $792.84 (Table 14), with a NPW of $241.35 per acre (Table 10). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 46.80 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 30 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 42 (Table 6). This optimal management regime will generate the maximum SEV of $22,176.79 (Table 14), with a NPW of $11,527.59 per acre (Table 10). This financially optimal rotation would produce an estimated 89.24 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 102.68 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 6). This

optimal management regime will generate the maximum SEV of $8,328.30 (Table 14), with a NPW of $4,186.15 per acre (Table 10). This financially optimal rotation would produce an estimated 40.28 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 52.83 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 6). This optimal management regime will generate the maximum SEV of $4,346.96 (Table 14), with a NPW of $2,398.86 per acre (Table 10). This financially optimal rotation would produce an estimated 40.28 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 52.83 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 6). This optimal management regime will generate the maximum SEV of $2,544.49 (Table 14), with a NPW of $1,352.76 per acre (Table 10). This financially optimal rotation would produce an estimated 34.04 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 47.80 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 6). This optimal management regime will generate the maximum SEV of $1,579.88 (Table 14), with a NPW of $752.25 per acre (Table 10). This financially optimal rotation would

produce an estimated 34.04 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 47.80 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 6). This optimal management regime will generate the maximum SEV of $992.84 (Table 14), with a NPW of $372.19 per acre (Table 10). This financially optimal rotation would produce an estimated 29.88 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 45.23 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 31 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 40 (Table 6). This optimal management regime will generate the maximum SEV of $24,476.68 (Table 14), with a NPW of $12,448.54 per acre (Table 10). This financially optimal rotation would produce an estimated 93.40 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 105.09 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 6). This optimal management regime will generate the maximum SEV of $9,331.29 (Table 14), with a NPW of $4,750.78 per acre (Table 10). This financially optimal rotation would

produce an estimated 45.23 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 57.07 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 6). This optimal management regime will generate the maximum SEV of $4,938.52 (Table 14), with a NPW of $2,602.68 per acre (Table 10). This financially optimal rotation would produce an estimated 35.13 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 49.18 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 6). This optimal management regime will generate the maximum SEV of $2,949.29 (Table 14), with a NPW of $1,577.99 per acre (Table 10). This financially optimal rotation would produce an estimated 32.03 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 46.40 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 6). This optimal management regime will generate the maximum SEV of $1,893.85 (Table 14), with a NPW of $953.20 per acre (Table 10). This financially optimal rotation would produce an estimated 32.03 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 46.40 net tons of carbon per acre during one rotation (Table 2).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 6). This optimal management regime will generate the maximum SEV of $1,243.49 (Table 14), with a NPW of $538.15 per acre (Table 10). This financially optimal rotation would produce an estimated 32.03 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 46.40 net tons of carbon per acre during one rotation (Table 2).

<u>California-Douglas-fir - Timber Only Rotations (C = $37/ton)</u>

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 32 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 45 (Table 7). This optimal management regime will generate the maximum SEV of $18,680.19 (Table 15), with a NPW of $12,681.13 per acre (Table 11). This means that $18,680.19 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $12,681.13 per acre for managing one rotation, or $18,680.19 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 87.91 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 103.44 net tons of carbon per acre during one rotation

(Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 26 (Table 7). This optimal management regime will generate the maximum SEV of $7,394.07 (Table 15), with a NPW of $5,413.58 per acre (Table 11). This financially optimal rotation would produce an estimated 45.72 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 58.28 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 7). This optimal management regime will generate the maximum SEV of $3,332.56 (Table 15), with a NPW of $2,653.68 per acre (Table 11). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 46.80 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 7). This optimal management regime will generate the maximum SEV of $1,878.84 (Table 15), with a NPW of $1,648.03 per acre (Table 11). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 46.80 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 7). This optimal management regime will generate the maximum SEV of $1,087.94 (Table 15), with a NPW of $1,006.42 per acre (Table 11). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 46.80 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 7). This optimal management regime will generate the maximum SEV of $617.40 (Table 15), with a NPW of $588.88 per acre (Table 11). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 46.80 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 30 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 42 (Table 7). This optimal management regime will generate the maximum SEV of $20,696.46 (Table 15), with a NPW of $13,538.82 per acre (Table 11). This financially optimal rotation would produce an estimated 89.24 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 102.68 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 7). This optimal management regime will generate the maximum SEV of $7,627.06 (Table 15), with a NPW of $5,374.77 per acre (Table 11). This financially optimal rotation would produce an estimated 45.74 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 57.73 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 7). This optimal management regime will generate the maximum SEV of $3,896.11 (Table 15), with a NPW of $3,157.80 per acre (Table 11). This financially optimal rotation would produce an estimated 45.74 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 57.73 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 7). This optimal management regime will generate the maximum SEV of $2,225.87 (Table 15), with a NPW of $1,925.09 per acre (Table 11). This financially optimal rotation would produce an estimated 34.04 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 47.80 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 7). This optimal management regime will generate the maximum SEV of $1,332.97 (Table 15), with a NPW of $1,220.60 per acre (Table 11). This financially optimal rotation would produce an estimated 34.04 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 47.80 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 7). This optimal management regime will generate the maximum SEV of $797.40 (Table 15), with a NPW of $754.69 per acre (Table 11). This financially optimal rotation would produce an estimated 34.04 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 47.80 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 30 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 42 (Table 7). This optimal management regime will generate the maximum SEV of $22,877.42 (Table 15), with a NPW of $14,965.52 per acre (Table 11). This financially optimal rotation would produce an estimated 99.05 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 109.89 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 7). This optimal management regime will generate the maximum SEV of $8,587.97 (Table 15), with a NPW of $5,791.98 per acre (Table 11). This financially optimal rotation would produce an estimated 45.23 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 57.07 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 7). This optimal management regime will generate the maximum SEV of $4,434.71 (Table 15), with a NPW of $3,594.34 per acre (Table 11). This financially optimal rotation would produce an estimated 45.23 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 57.07 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 7). This optimal management regime will generate the maximum SEV of $2,601.53 (Table 15), with a NPW of $2,176.16 per acre (Table 11). This financially optimal rotation would produce an estimated 32.03 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 46.40 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 7). This

optimal management regime will generate the maximum SEV of $1,625.14 (Table 15), with a NPW of $1,451.76 per acre (Table 11). This financially optimal rotation would produce an estimated 32.03 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 46.40 net tons of carbon per acre during one rotation (Table 3).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 7). This optimal management regime will generate the maximum SEV of $1,027.47 (Table 15), with a NPW of $955.27 per acre (Table 11). This financially optimal rotation would produce an estimated 32.03 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 46.40 net tons of carbon per acre during one rotation (Table 3).

California- Douglas-fir - Timber Only Rotations (C = $50/ton)

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 32 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 45 (Table 8). This optimal management regime will generate the maximum SEV of $20,080.34 (Table 16), with a NPW of $13,631.63 per acre (Table 12). This means that $20,080.34 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $13,631.63 per acre for managing one rotation, or $20,080.34

per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 87.91 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 103.44 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which final harvest is conducted at stand age 26 (Table 8). This optimal management regime will generate the maximum SEV of $6,742.71 (Table 16), with a NPW of $4,936.69 per acre (Table 12). This financially optimal rotation would produce an estimated 45.72 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 58.28 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 8). This optimal management regime will generate the maximum SEV of $3,732.46 (Table 16), with a NPW of $3,163.12 per acre (Table 12). This financially optimal rotation would produce an estimated 42.92 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 56.05 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 8). This

optimal management regime will generate the maximum SEV of $2,169.98 (Table 16), with a NPW of $1,903.41 per acre (Table 12). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 46.80 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 8). This optimal management regime will generate the maximum SEV of $1,310.84 (Table 16), with a NPW of $1,212.62 per acre (Table 12). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 46.80 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 8). This optimal management regime will generate the maximum SEV of $792.84 (Table 16), with a NPW of $756.21 per acre (Table 12). This financially optimal rotation would produce an estimated 32.13 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 46.80 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 30 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 42 (Table 8). This optimal management regime will generate the maximum SEV of $22,176.79 (Table

16), with a NPW of $14,507.19 per acre (Table 12). This financially optimal rotation would produce an estimated 89.24 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 102.68 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 19 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 24 (Table 8). This optimal management regime will generate the maximum SEV of $8,328.30 (Table 16), with a NPW of $5,868.93 per acre (Table 12). This financially optimal rotation would produce an estimated 44.63 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 60.24 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 8). This optimal management regime will generate the maximum SEV of $4,346.96 (Table 16), with a NPW of $3,523.22 per acre (Table 12). This financially optimal rotation would produce an estimated 40.28 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 52.83 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 8). This optimal management regime will generate the maximum SEV of $2,544.49 (Table 16),

with a NPW of $2,200.66 per acre (Table 12). This financially optimal rotation would produce an estimated 34.04 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 47.80 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 8). This optimal management regime will generate the maximum SEV of $1,579.23 (Table 16), with a NPW of $1,446.11 per acre (Table 12). This financially optimal rotation would produce an estimated 34.04 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 47.80 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 8). This optimal management regime will generate the maximum SEV of $992.84 (Table 16), with a NPW of $940.09 per acre (Table 12). This financially optimal rotation would produce an estimated 34.04 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 47.80 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 30 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 42 (Table 8). This optimal management regime will generate the maximum SEV of $24,478.68 (Table 16), with a NPW of $16,013.00 per acre (Table 12). This financially optimal rotation

would produce an estimated 99.05 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 106.89 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 8). This optimal management regime will generate the maximum SEV of $9,331.29 (Table 16), with a NPW of $6,293.29 per acre (Table 12). This financially optimal rotation would produce an estimated 45.23 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 57.07 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 8). This optimal management regime will generate the maximum SEV of $4,938.52 (Table 16), with a NPW of $4,002.68 per acre (Table 12). This financially optimal rotation would produce an estimated 45.23 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 57.07 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 8). This optimal management regime will generate the maximum SEV of $2,949.29 (Table 16), with a NPW of $2,510.90 per acre (Table 12). This financially optimal rotation would

produce an estimated 35.13 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 49.18 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 8). This optimal management regime will generate the maximum SEV of $1,893.85 (Table 16), with a NPW of $1,691.81 per acre (Table 12). This financially optimal rotation would produce an estimated 32.03 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 46.40 net tons of carbon per acre during one rotation (Table 4).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 8). This optimal management regime will generate the maximum SEV of $1,243.49 (Table 16), with a NPW of $1,156.11 per acre (Table 12). This financially optimal rotation would produce an estimated 32.03 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 46.40 net tons of carbon per acre during one rotation (Table 4).

Species <u>   Douglas-fir   </u> Region <u>Eastside Cascades</u>

Site indices 100, 110 and 120 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 4.5-in. inside bark top diameter for trees with a minimum of 7 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 9-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 15 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.187943262 and 0.709219858, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Gower et al (1987) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Y = -1.532 + 2.798 \log X$$

where:

Y = component dry weight (kg)

X = stem diameter (cm)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.6% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $331/mbf (Scribner) (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices) and pulpwood price was assumed to be $0/cord (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of Douglas-fir plantations in the Eastside Cascades.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$80.28	Only once	Year 0	
Seedlings[b] (600 seedlings/ac)	$162	Only Once	Year 0	
Burning[a]	$21.24	Every 5 years	Year 10	Final Harvest
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al (2005).

[b]The seedling cost was estimated based on the seedling prices from Source of Oregon Native Forest Tree Seedlings 2004-2005 by elevation (http://egov.oregon.gov/ODF/PRIVATE_FORESTS/docs/2004Catalog.pdf. February 12, 2006).

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Table 23. Total tons of carbon sequestered per acre for Douglas fir plantations in the Eastside Cascades United States by site index and real alternative rates of return. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	27.09	16.48	15.79	15.79	14.62	14.62
110	27.04	15.58	15.58	14.59	13.62	13.62
120	28.68	16.39	16.39	16.39	16.39	16.39

[1]Base age 50.

Table 24. Total tons of carbon sequestered per acre for Douglas fir plantations in the Eastside Cascades United States by site index and real alternative rates of return. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	27.09	16.48	15.79	15.79	14.62	14.62
110	27.04	15.58	15.58	14.59	13.62	13.62
120	28.68	16.39	16.39	16.39	16.39	16.39

[1]Base age 50.

Table 25. Total tons of carbon sequestered per acre for Douglas fir plantations in the Eastside Cascades United States by site index and real alternative rates of return. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	30.62	16.48	16.48	15.79	14.62	14.62
110	27.04	15.58	15.58	14.59	14.59	13.62
120	28.68	16.39	16.39	16.39	16.39	16.39

[1]Base age 50.

Table 26. Total tons of carbon sequestered per acre for Douglas fir plantations in the Eastside Cascades United States by site index and real alternative rates of return. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	30.62	16.48	16.48	15.79	14.62	14.62
110	31.03	15.58	15.58	14.59	14.59	13.62
120	28.68	16.39	16.39	16.39	16.39	16.39

[1]Base age 50.

Table 27. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in the Eastside Cascades United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	38-46-**54**[2] (30%)	26-**33** (25%)[3]	<26-**32**>[4] (25%)	<26-**32**> (25%)	<25-**30**> (30%)	<25-**30**> (30%)
110	34-39-**49** (30%)	**31**	**31**	**<29>**	**<27>**	**<27>**
120	31-37-**46** (30%)	21-**27** (25%)	21-**27** (25%)	<21-**27**> (25%)	<21-**27**> (25%)	<21-**27**> (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 28. Financially optimal thinning and final harvest schedules which maximize soil expectation value Douglas fir plantations by site index and real alternative rates of return in the Eastside Cascades United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	38-46-**54**[2] (30%)[3]	26-**33** (25%)	26-**32** (25%)	<26-**32**>[4] (25%)	<25-**30**> (30%)	<25-**30**> (30%)
110	34-39-**49** (30%)	**31**	**31**	**<29>**	**<27>**	**<27>**
120	31-37-**46** (30%)	21-**27** (25%)	21-**27** (25%)	<21-**27**> (25%)	<21-**27**> (25%)	<21-**27**> (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 29. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in the Eastside Cascades United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	37-50-**59**[2] (30%)[3]	26-**33** (25%)	26-**33** (25%)	<26-**32>**[4] (25%)	<25-**30**> (30%)	<25-**30**> (30%)
110	34-39-**49** (30%)	**31**	**31**	**29**	**<29>**	**<27>**
120	31-37-**46** (30%)	21-**27** (25%)	21-**27** (25%)	21-**27** (25%)	<21-**27>** (25%)	<21-**27>** (25%)

[1] Base age 50.
[2] Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3] Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4] Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 30. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in the Eastside Cascades United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	37-50-**59**[2] (30%)[3]	26-**33** (25%)	26-**33** (25%)	26-**32** (25%)	<25-**30**>[4] (30%)	<25-**30**> (30%)
110	33-45-**54 (**30%**)**	**31**	**31**	**29**	**<29>**	**<27>**
120	31-37-**46** (30%)	21-**27** (25%)	21-**27** (25%)	21-**27** (25%)	21-**27** (25%)	<21-**27>** (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 31. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the Eastside Cascades United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$1,998.39	$409.74	-$40.65	-$238.76	-$324.72	-$367.57
110	$2,351.91	$557.53	$48.11	-$181.70	-$289.60	-$344.70
120	$2,782.33	$765.55	$206.64	-$82.40	-$233.74	-$313.84

[1]Base age 50.

Table 32. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the Eastside Cascades United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$2,175.14	$502.01	$27.75	-$186.02	-$284.24	-$335.03
110	$2,533.97	$653.11	$122.14	-$125.49	-$245.90	-$309.10
120	$2,976.96	$864.56	$284.18	-$20.96	-$184.39	-$273.63

[1]Base age 50.

Table 33. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the Eastside Cascades United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$2,759.21	$751.14	$215.16	-$43.60	-$174.92	-$247.16
110	$3,025.55	$911.18	$322.00	$26.27	-$127.86	-$213.00
120	$3,502.46	$1,131.87	$493.54	$144.92	-$51.15	-$165.06

[1]Base age 50.

Table 34. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the Eastside Cascades United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$3,006.56	$871.09	$305.69	$24.98	-$122.29	-$204.85
110	$3,422.98	$1,035.44	$418.23	$99.34	-$69.55	-$166.72
120	$3,755.48	$1,260.58	$594.35	$224.80	$13.00	-$112.79

[1]Base age 50.

Table 35. Soil expectation value of the financially optimal thinning and final harvest schedules Douglas fir plantations by site index and real alternative rates of return in the Eastside Cascades United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$2,690.17	$506.07	-$44.76	-$249.51	-$333.38	-$372.47
110	$3,316.95	$705.61	$53.39	-$192.75	-$300.72	-$351.72
120	$4,051.82	$1,027.71	$238.06	-$88.54	-$242.71	-$320.23

[1]Base age 50.

Table 36. Soil expectation value of the financially optimal thinning and final harvest schedules Douglas fir plantations by site index and real alternative rates of return in the Eastside Cascades United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$2,928.10	$620.03	$30.56	-$194.39	-$291.81	-$339.49
110	$3,573.72	$826.58	$135.53	-$133.12	-$255.34	-$315.40
120	$4,335.25	$1,160.62	$327.39	-$22.53	-$191.47	-$279.20

[1]Base age 50.

Table 37. Soil expectation value of the financially optimal thinning and final harvest schedules Douglas fir plantations by site index and real alternative rates of return in the Eastside Cascades United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$3,570.80	$927.74	$235.28	-$45.56	-$179.58	-$250.45
110	$4,267.00	$1,153.20	$357.32	$27.87	-$131.70	-$217.34
120	$5,100.52	$1,519.48	$568.59	$155.72	-$53.11	-$168.43

[1]Base age 50.

Table 38. Soil expectation value of the financially optimal thinning and final harvest schedules Douglas fir plantations by site index and real alternative rates of return in the Eastside Cascades United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$3,890.89	$1,075.89	$334.28	$26.10	-$125.55	-$207.57
110	$4,607.91	$1,310.46	$464.10	$105.38	-$71.64	-$170.12
120	$5,468.98	$1,692.26	$684.73	$241.55	$13.50	-$115.09

[1]Base age 50.

Table 39. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in the Eastside Cascades United States. (carbon value = $0/ton)

			1st thinning	2nd thinning	Final Harvest	Total Volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
100	2.50%	38-46-**54**[3] (30%)[4]	4.74	4.82	16.44	26.01
	5.00%	26-**33** (25%)[3]	0	-[5]	13.74	13.74
	7.50%	<26-**32**> (25%)	0	-	12.87	12.87
	10.00%	<26-**32**> (25%)	0	-	12.87	12.87
	12.50%	<25-**30**> (30%)	0	-	10.79	10.79
	15.00%	<25-**30**> (30%)	0	-	10.79	10.79
110	2.50%	34-39-**49 (**30%**)**	4.57	4.52	17.31	26.41
	5.00%	**31**	-	-	14.63	14.63
	7.50%	**31**	-	-	14.63	14.63
	10.00%	**<29>**	-	-	12.49	12.49
	12.50%	**<27>**	-	-	10.23	10.23
	15.00%	**<27>**	-	-	10.23	10.23
120	2.50%	31-37-**46** (30%)	4.72	4.86	18.99	28.57
	5.00%	21-**27** (25%)	0	-	14.5	14.5
	7.50%	21-**27** (25%)	0	-	14.5	14.5
	10.00%	<21-**27**> (25%)	0	-	14.5	14.5
	12.50%	<21-**27**> (25%)	0	-	14.5	14.5

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 40. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in the Eastside Cascades United States. (carbon value = $10/ton)

			1st thinning	2nd thinning	Final Harvest	Total Volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
100	2.50%	38-46-**54**[3] (30%)[4]	4.74	4.82	16.44	26.01
	5.00%	26-**33** (25%)	0	-[5]	13.74	13.74
	7.50%	26-**32** (25%)	0	-	12.87	12.87
	10.00%	<26-**32**> (25%)	0	-	12.87	12.87
	12.50%	<25-**30**> (30%)	0	-	10.79	10.79
	15.00%	<25-**30**> (30%)	0	-	10.79	10.79
110	2.50%	34-39-**49 (**30%**)**	4.57	4.52	17.31	26.41
	5.00%	**31**	-	-	14.63	14.63
	7.50%	**31**	-	-	14.63	14.63
	10.00%	**<29>**	-	-	12.49	12.49
	12.50%	**<27>**	-	-	10.23	10.23
	15.00%	**<27>**	-	-	10.23	10.23
120	2.50%	31-37-**46** (30%)	4.72	4.86	18.99	28.57
	5.00%	21-**27** (25%)	0	-	14.5	14.5
	7.50%	21-**27** (25%)	0	-	14.5	14.5
	10.00%	<21-**27**> (25%)	0	-	14.5	14.5
	12.50%	<21-**27**> (25%)	0	-	14.5	14.5
	15.00%	<21-**27**> (25%)	0	-	14.5	14.5

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 41. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in the Eastside Cascades United States. (carbon value = $37/ton)

			1st thinning	2nd thinning	Final Harvest	Total Volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
100	2.50%	37-50-**59**[3] (30%)[4]	4.47	5.48	19.25	29.21
	5.00%	26-**33** (25%)	0	-[5]	13.74	13.74
	7.50%	26-**33** (25%)	0	-	13.74	13.74
	10.00%	<26-**32**> (25%)	0	-	12.87	12.87
	12.50%	<25-**30**> (30%)	0	-	10.79	10.79
	15.00%	<25-**30**> (30%)	0	-	10.79	10.79
110	2.50%	34-39-**49** (30%)	4.57	4.52	17.31	26.41
	5.00%	**31**	-	-	14.63	14.63
	7.50%	**31**	-	-	14.63	14.63
	10.00%	**29**	-	-	12.49	12.49
	12.50%	**<29>**	-	-	12.49	12.49
	15.00%	**<27>**	-	-	10.23	10.23
120	2.50%	31-37-**46** (30%)	4.72	4.86	18.99	28.57
	5.00%	21-**27** (25%)	0	-	14.5	14.5
	7.50%	21-**27** (25%)	0	-	14.5	14.5
	10.00%	21-**27** (25%)	0	-	14.5	14.5
	12.50%	<21-**27**> (25%)	0	-	14.5	14.5
	15.00%	<21-**27**> (25%)	0	-	14.5	14.5

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 42. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in the Eastside Cascades United States. (carbon value = $50/ton)

			1st thinning	2nd thinning	Final Harvest	Total Volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
100	2.50%	37-50-**59**[3] (30%)[4]	4.47	5.48	19.25	29.21
	5.00%	26-**33** (25%)	0	-[5]	13.74	13.74
	7.50%	26-**33** (25%)	0	-	13.74	13.74
	10.00%	<26-**32**> (25%)	0	-	12.87	12.87
	12.50%	<25-**30**> (30%)	0	-	10.79	10.79
	15.00%	<25-**30**> (30%)	0	-	10.79	10.79
110	2.50%	33-45-**54 (**30%**)**	4.21	5.64	20.24	30.09
	5.00%	**31**	-	-	14.63	14.63
	7.50%	**31**	-	-	14.63	14.63
	10.00%	**29**	-	-	12.49	12.49
	12.50%	**<29>**	-	-	12.49	12.49
	15.00%	**<27>**	-	-	10.23	10.23
120	2.50%	31-37-**46** (30%)	4.72	4.86	18.99	28.57
	5.00%	21-**27** (25%)	0	-	14.5	14.5
	7.50%	21-**27** (25%)	0	-	14.5	14.5
	10.00%	21-**27** (25%)	0	-	14.5	14.5
	12.50%	21-**27** (25%)	0	-	14.5	14.5
	15.00%	<21-**27**> (25%)	0	-	14.5	14.5

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 43. Financially optimal thinning and final harvest schedules for Douglas fir plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	100	38-46-**54**[2] (30%)[3]	38-46-**54** (30%)	0%	37-50-**59** (30%)	9%	37-50-**59** (30%)	9%
	110	34-39-**49** (30%)	34-39-**49** (30%)	0%	34-39-**49** (30%)	0%	33-45-**54** (30%)	10%
	120	31-37-**46** (30%)	31-37-**46** (30%)	0%	31-37-**46** (30%)	0%	31-37-**46** (30%)	0%
5.00%	100	26-**33** (25%)[3]	26-**33** (25%)	0%	26-**33** (25%)	0%	26-**33** (25%)	0%
	110	**31**	**31**	0%	**31**	0%	**31**	0%
	120	21-**27** (25%)	21-**27** (25%)	0%	21-**27** (25%)	0%	21-**27** (25%)	0%
7.50%	100	<26-**32**>[4] (25%)	26-**32** (25%)	0%	26-**33** (25%)	3%	26-**33** (25%)	3%
	110	**31**	**31**	0%	**31**	0%	**31**	0%
	120	21-**27** (25%)	21-**27** (25%)	0%	21-**27** (25%)	0%	21-**27** (25%)	0%
10.00%	100	<26-**32**> (25%)	<26-**32**> (25%)	0%	<26-**32**> (25%)	0%	26-**32** (25%)	0%
	110	**<29>**	**<29>**	0%	**29**	0%	**29**	0%
	120	<21-**27**> (25%)	<21-**27**> (25%)	0%	21-**27** (25%)	0%	21-**27** (25%)	0%
12.50%	100	<25-**30**> (30%)	<25-**30**> (30%)	0%	<25-**30**> (30%)	0%	<25-**30**> (30%)	0%
	110	**<27>**	**<27>**	0%	**<29>**	7%	**<29>**	7%
	120	<21-**27**> (25%)	<21-**27**> (25%)	0%	<21-**27**> (25%)	0%	21-**27** (25%)	0%
15.00%	100	<25-**30**> (30%)	<25-**30**> (30%)	0%	<25-**30**> (30%)	0%	<25-**30**> (30%)	0%
	110	**<27>**	**<27>**	0%	**<27>**	0%	**<27>**	0%
	120	<21-**27**> (25%)	<21-**27**> (25%)	0%	<21-**27**> (25%)	0%	<21-**27**> (25%)	0%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3] Number in parentheses indicates the percentage of basal area removed during thinning

[4] <> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 44. The soil expectation value ($/acre) of the financially optimal rotations for Douglas fir plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	2,690.17	2,928.10	9%	3,570.80	33%	3,890.89	45%
	80	3,316.95	3,573.72	8%	4,267.00	29%	4,607.91	39%
	90	4,051.82	4,335.25	7%	5,100.52	26%	5,468.98	35%
5.00%	70	506.07	620.03	23%	927.74	83%	1,075.89	113%
	80	705.61	826.58	17%	1,153.20	63%	1,310.46	86%
	90	1,027.71	1,160.62	13%	1,519.48	48%	1,692.26	65%
7.50%	70	-44.76	30.56		235.28		334.28	
	80	53.39	135.53	154%	357.32	569%	464.10	769%
	90	238.06	327.39	38%	568.59	139%	684.73	188%
10.00%	70	-249.51	-194.39		-45.56		26.10	
	80	-192.75	-133.12		27.87		105.38	
	90	-88.54	-22.53		155.72		241.55	
12.50%	70	-333.38	-291.81		-179.58		-125.55	
	80	-300.72	-255.34		-131.70		-71.64	
	90	-242.71	-191.47		-53.11		13.50	
15.00%	70	-372.47	-339.49		-250.45		-207.57	
	80	-351.72	-315.40		-217.34		-170.12	
	90	-320.23	-279.20		-168.43		-115.09	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>Eastside Cascades- Douglas-fir - Timber Only Rotations (C = $0/ton)</u>

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 27). This optimal management regime will generate the maximum SEV of $2,690.17 (Table 35), with a NPW of $1,998.39 per acre (Table 31). This means that $2,690.17 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,998.39 per acre for managing one rotation, or $2,690.17 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 26.01 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 27.09 net tons of carbon per acre during one rotation (Table 23). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 27). This optimal management regime will generate the maximum SEV of $506.07 (Table 35), with a NPW of $409.74 per acre (Table 31). This financially optimal rotation would

produce an estimated 13.74 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 16.48 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 32 (Table 27). This optimal management regime will generate the maximum SEV of -$44.76 (Table 35), with a NPW of -$40.65 per acre (Table 31). This financially optimal rotation would produce an estimated 12.87 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 15.79 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 32 (Table 27). This optimal management regime will generate the maximum SEV of -$249.51 (Table 35), with a NPW of -$238.76 per acre (Table 31). This financially optimal rotation would produce an estimated 12.87 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 15.79 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 30 (Table 27). This optimal management regime will generate the maximum SEV of -\$333.38 (Table 35), with a NPW of -\$324.72 per acre (Table 31). This financially optimal rotation would produce an estimated 10.79 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 14.62 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = \$0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 30 (Table 27). This optimal management regime will generate the maximum SEV of -\$372.47 (Table 35), with a NPW of -\$367.57 per acre (Table 31). This financially optimal rotation would produce an estimated 10.79 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 14.62 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = \$0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 27). This optimal management regime will generate the maximum SEV of \$3,316.95 (Table 35), with a NPW of \$2,351.91 per acre (Table 31). This financially optimal rotation would produce an estimated 26.41 MBF of sawlogs per acre from the thinning

and final harvest (Table 39), and sequester 27.04 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 31 (Table 27). This optimal management regime will generate the maximum SEV of $705.61 (Table 35), with a NPW of $557.53 per acre (Table 31). This financially optimal rotation would produce an estimated 14.63 MBF of sawlogs per acre from the final harvest (Table 39), and sequester 15.58 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 31 (Table 27). This optimal management regime will generate the maximum SEV of $53.39 (Table 35), with a NPW of $48.11 per acre (Table 31). This financially optimal rotation would produce an estimated 14.63 MBF of sawlogs per acre from the final harvest (Table 39), and sequester 15.58 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 27). This optimal management regime will generate the maximum SEV of -$192.75 (Table 35), with a NPW of -$181.70 per acre (Table 31). This financially optimal rotation would produce an estimated 12.49 MBF of sawlogs per acre from the final harvest (Table 39), and sequester 14.59 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 27). This optimal management regime will generate the maximum SEV of -$300.72 (Table 35), with a NPW of -$289.60 per acre (Table 31). This financially optimal rotation would produce an estimated 10.23 MBF of sawlogs per acre from the final harvest (Table 39), and sequester 13.62 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 27). This optimal management regime will generate the maximum SEV of -$351.72 (Table 35), with a NPW of -$344.70 per acre (Table 31). This financially optimal rotation would produce an estimated 10.23 MBF of sawlogs per acre from the final harvest (Table 39), and sequester 13.62 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 37 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 27). This optimal management regime will generate the maximum SEV of $4,051.82 (Table 35), with a NPW of $2,782.33 per acre (Table 31). This financially optimal rotation would produce an estimated 28.57 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 28.68 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 27). This optimal management regime will generate the maximum SEV of $1,027.71 (Table 35), with a NPW of $765.55 per acre (Table 31). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 16.39 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 27). This optimal management regime will generate the maximum SEV of $238.06 (Table 35), with a NPW of $206.64 per acre (Table 31). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 16.39 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 27). This optimal management regime will generate the maximum SEV of -$88.54 (Table 35), with

a NPW of -$82.40 per acre (Table 31). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 16.39 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 27). This optimal management regime will generate the maximum SEV of -$242.71 (Table 35), with a NPW of -$233.74 per acre (Table 31). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 16.39 net tons of carbon per acre during one rotation (Table 23).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 27). This optimal management regime will generate the maximum SEV of -$320.23 (Table 35), with a NPW of -$313.84 per acre (Table 31). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 16.39 net tons of carbon per acre during one rotation (Table 23).

<u>Eastside Cascades- Douglas-fir - Timber Only Rotations (C = $10/ton)</u>

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 28). This optimal management regime will generate the maximum SEV of $2,928.10 (Table 36), with a NPW of $2,175.14 per acre (Table 32). This means that $2,928.10 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,175.14 per acre for managing one rotation, or $2,928.10 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 26.01 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 27.09 net tons of carbon per acre during one rotation (Table 24). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 28). This optimal management regime will generate the maximum SEV of $620.03 (Table 36), with a NPW of $502.01 per acre (Table 32). This financially optimal rotation would

produce an estimated 13.74 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 16.48 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 32 (Table 28). This optimal management regime will generate the maximum SEV of $30.56 (Table 36), with a NPW of $27.75 per acre (Table 32). This financially optimal rotation would produce an estimated 12.87 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 15.79 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 32 (Table 28). This optimal management regime will generate the maximum SEV of -$194.39 (Table 36), with a NPW of -$186.02 per acre (Table 32). This financially optimal rotation would produce an estimated 12.87 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 15.79 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 30 (Table 28). This optimal management regime will generate the maximum SEV of -$291.81 (Table 36), with a NPW of -$284.24 per acre (Table 32). This financially optimal rotation would produce an estimated 10.79 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 14.62 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 30 (Table 28). This optimal management regime will generate the maximum SEV of -$339.49 (Table 36), with a NPW of -$335.03 per acre (Table 32). This financially optimal rotation would produce an estimated 10.79 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 14.62 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 28). This optimal management regime will generate the maximum SEV of $3,573.72 (Table 36), with a NPW of $2,533.97 per acre (Table 32). This financially optimal rotation would produce an estimated 26.41 MBF of sawlogs per acre from the thinning

and final harvest (Table 40), and sequester 27.04 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 31 (Table 28). This optimal management regime will generate the maximum SEV of $826.58 (Table 36), with a NPW of $653.11 per acre (Table 32). This financially optimal rotation would produce an estimated 14.63 MBF of sawlogs per acre from the final harvest (Table 40), and sequester 15.58 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 31 (Table 28). This optimal management regime will generate the maximum SEV of $135.53 (Table 36), with a NPW of $122.14 per acre (Table 32). This financially optimal rotation would produce an estimated 14.63 MBF of sawlogs per acre from the final harvest (Table 40), and sequester 15.58 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 28). This optimal management regime will generate the maximum SEV of -$133.12 (Table 36), with a NPW of -$125.49 per acre (Table 32). This financially optimal rotation would produce an estimated 12.49 MBF of sawlogs per acre from the final harvest (Table 40), and sequester 14.59 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 28). This optimal management regime will generate the maximum SEV of -$255.34 (Table 36), with a NPW of -$245.90 per acre (Table 32). This financially optimal rotation would produce an estimated 10.23 MBF of sawlogs per acre from the final harvest (Table 40), and sequester 13.62 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 28). This optimal management regime will generate the maximum SEV of -$315.40 (Table 36), with a NPW of -$309.10 per acre (Table 32). This financially optimal rotation would produce an estimated 10.23 MBF of sawlogs per acre from the final harvest (Table 40), and sequester 13.62 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 37 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 28). This optimal management regime will generate the maximum SEV of $4,335.25 (Table 36), with a NPW of $2,976.96 per acre (Table 32). This financially optimal rotation would produce an estimated 28.57 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 28.68 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 28). This optimal management regime will generate the maximum SEV of $1,160.62 (Table 36), with a NPW of $864.56 per acre (Table 32). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 16.39 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 28). This optimal management regime will generate the maximum SEV of $327.39 (Table 36), with a NPW of $284.18 per acre (Table 32). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 16.39 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 28). This optimal management regime will generate the maximum SEV of -$22.53 (Table 36), with

a NPW of -$20.96 per acre (Table 32). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 16.39 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 28). This optimal management regime will generate the maximum SEV of -$191.47 (Table 36), with a NPW of -$184.39 per acre (Table 32). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 16.39 net tons of carbon per acre during one rotation (Table 24).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 28). This optimal management regime will generate the maximum SEV of -$279.20 (Table 36), with a NPW of -$273.63 per acre (Table 32). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 16.39 net tons of carbon per acre during one rotation (Table 24).

<u>Eastside Cascades-Douglas-fir - Timber Only Rotations (C = $37/ton)</u>

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 50 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 29). This optimal management regime will generate the maximum SEV of $3,570.80 (Table 37), with a NPW of $2,759.21 per acre (Table 33). This means that $3,570.80 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,759.21 per acre for managing one rotation, or $3,570.80 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 29.21 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 30.62 net tons of carbon per acre during one rotation (Table 25). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 29). This optimal management regime will generate the maximum SEV of $927.74 (Table 37), with a NPW of $751.14 per acre (Table 33). This financially optimal rotation would

produce an estimated 13.74 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 16.48 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 29). This optimal management regime will generate the maximum SEV of $235.28 (Table 37), with a NPW of $215.16 per acre (Table 33). This financially optimal rotation would produce an estimated 13.74 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 16.48 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 32 (Table 29). This optimal management regime will generate the maximum SEV of -$45.56 (Table 37), with a NPW of -$43.60 per acre (Table 33). This financially optimal rotation would produce an estimated 12.87 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 15.79 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 30 (Table 29). This optimal management regime will generate the maximum SEV of -$179.58 (Table 37), with a NPW of -$174.92 per acre (Table 33). This financially optimal rotation would produce an estimated 10.79 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 14.62 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 30 (Table 29). This optimal management regime will generate the maximum SEV of -$250.45 (Table 37), with a NPW of -$247.16 per acre (Table 33). This financially optimal rotation would produce an estimated 10.79 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 14.62 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 29). This optimal management regime will generate the maximum SEV of $4,267.00 (Table 37), with a NPW of $3,025.55 per acre (Table 33). This financially optimal rotation would produce an estimated 26.41 MBF of sawlogs per acre from the final harvest (Table 41), and sequester 27.04 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 31 (Table 29). This optimal management regime will generate the maximum SEV of $1,153.20 (Table 37), with a NPW of $911.18 per acre (Table 33). This financially optimal rotation would produce an estimated 14.63 MBF of sawlogs per acre from the final harvest (Table 41), and sequester 15.58 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 31 (Table 29). This optimal management regime will generate the maximum SEV of $357.32 (Table 37), with a NPW of $322.00 per acre (Table 33). This financially optimal rotation would produce an estimated 14.63 MBF of sawlogs per acre from the final harvest (Table 41), and sequester 15.58 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 29). This optimal management regime will generate the maximum SEV of $27.87 (Table 37), with a NPW of $26.27 per acre (Table 33). This financially optimal rotation would produce an estimated 12.49 MBF of sawlogs per acre from the final harvest (Table 41), and sequester 14.59 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 29). This optimal management regime will generate the maximum SEV of -$131.70 (Table 37), with a NPW of -$127.86 per acre (Table 33). This financially optimal rotation would produce an estimated 12.49 MBF of sawlogs per acre from the final harvest (Table 41), and sequester 14.59 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 29). This optimal management regime will generate the maximum SEV of -$217.34 (Table 37), with a NPW of -$213.00 per acre (Table 33). This financially optimal rotation would produce an estimated 10.23 MBF of sawlogs per acre from the final harvest (Table 41), and sequester 13.62 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 37 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 29). This optimal management regime will generate the maximum SEV of $5,100.52 (Table 37), with a NPW of $3,502.46 per acre (Table 33). This financially optimal rotation would produce an estimated 28.57 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 28.68 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 29). This optimal management regime will generate the maximum SEV of $1,519.48 (Table 37), with a NPW of $1,131.87 per acre (Table 33). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 16.39 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 29). This optimal management regime will generate the maximum SEV of $568.59 (Table 37), with a NPW of $493.54 per acre (Table 33). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 16.39 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 29). This optimal management regime will generate the maximum SEV of $155.72 (Table 37),

with a NPW of $144.92 per acre (Table 33). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 16.39 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 29). This optimal management regime will generate the maximum SEV of -$53.11 (Table 37), with a NPW of -$51.15 per acre (Table 33). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 16.39 net tons of carbon per acre during one rotation (Table 25).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 29). This optimal management regime will generate the maximum SEV of -$168.43 (Table 37), with a NPW of -$165.06 per acre (Table 33). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 16.39 net tons of carbon per acre during one rotation (Table 25).

Eastside Cascades- Douglas-fir - Timber Only Rotations (C = $50/ton)

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 50 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 30). This optimal management regime will generate the maximum SEV of $3,890.89 (Table 38), with a NPW of $3,006.56 per acre (Table 34). This means that $3,890.89 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $3,006.56 per acre for managing one rotation, or $3,890.89 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 29.21 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 30.62 net tons of carbon per acre during one rotation (Table 26). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 30). This optimal management regime will generate the maximum SEV of $1,075.89 (Table 38), with a NPW of $871.09 per acre (Table 34). This financially optimal rotation would

produce an estimated 13.74 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 16.48 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 30). This optimal management regime will generate the maximum SEV of $334.28 (Table 38), with a NPW of $305.69 per acre (Table 34). This financially optimal rotation would produce an estimated 13.74 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 16.48 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 32 (Table 30). This optimal management regime will generate the maximum SEV of $26.10 (Table 38), with a NPW of $24.98 per acre (Table 34). This financially optimal rotation would produce an estimated 12.87 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 15.79 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 30 (Table 30). This optimal management regime will generate the maximum SEV of -$125.55 (Table 38), with a NPW of -$122.29 per acre (Table 34). This financially optimal rotation would produce an estimated 10.79 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 14.62 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 30 (Table 30). This optimal management regime will generate the maximum SEV of -$207.57 (Table 38), with a NPW of -$204.85 per acre (Table 34). This financially optimal rotation would produce an estimated 10.79 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 14.62 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 30). This optimal management regime will generate the maximum SEV of $4,607.91 (Table 38), with a NPW of $3,422.98 per acre (Table 34). This financially optimal rotation would produce an estimated 30.09 MBF of sawlogs per acre from the thinning

and final harvest (Table 42), and sequester 31.03 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 31 (Table 30). This optimal management regime will generate the maximum SEV of $1,310.46 (Table 38), with a NPW of $1,035.44 per acre (Table 34). This financially optimal rotation would produce an estimated 14.63 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 15.58 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 31 (Table 30). This optimal management regime will generate the maximum SEV of $464.10 (Table 38), with a NPW of $418.23 per acre (Table 34). This financially optimal rotation would produce an estimated 14.63 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 15.58 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 30). This optimal management regime will generate the maximum SEV of $105.38 (Table 38), with a NPW of $99.34 per acre (Table 34). This financially optimal rotation would produce an estimated 12.49 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 14.59 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 30). This optimal management regime will generate the maximum SEV of -$71.64 (Table 38), with a NPW of -$69.55 per acre (Table 34). This financially optimal rotation would produce an estimated 12.49 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 14.59 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 30). This optimal management regime will generate the maximum SEV of -$170.12 (Table 38), with a NPW of -$166.72 per acre (Table 34). This financially optimal rotation would produce an estimated 10.23 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 13.62 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 37 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 30). This optimal management regime will generate the maximum SEV of $5,468.98 (Table 38), with a NPW of $3,755.48 per acre (Table 34). This financially optimal rotation would produce an estimated 28.57 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 28.68 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 30). This optimal management regime will generate the maximum SEV of $1,692.26 (Table 38), with a NPW of $1,260.58 per acre (Table 34). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 16.39 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 30). This optimal management regime will generate the maximum SEV of $684.73 (Table 38), with a NPW of $594.35 per acre (Table 34). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 16.39 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 30). This optimal management regime will generate the maximum SEV of $241.55 (Table 38),

with a NPW of $224.80 per acre (Table 34). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 16.39 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 30). This optimal management regime will generate the maximum SEV of $13.50 (Table 38), with a NPW of $13.00 per acre (Table 34). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 16.39 net tons of carbon per acre during one rotation (Table 26).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 30). This optimal management regime will generate the maximum SEV of -$115.09 (Table 38), with a NPW of -$112.79 per acre (Table 34). This financially optimal rotation would produce an estimated 14.50 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 16.39 net tons of carbon per acre during one rotation (Table 26).

Species Douglas-fir Region Pacific Northwest Coast

Site indices 100, 110 and 120 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 4.5-in. inside bark top diameter for trees with a minimum of 7 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 9-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 15 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.187943262 and 0.709219858, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Grier and Logan (1977) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Y = \exp(-2.656 + 2.530 \ln X)$$

where:

Y = component dry weight (kg)

X = stem diameter at breast height (cm)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.6% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be \$331/mbf (Scribner) (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices) and pulpwood price was assumed to be \$0/cord (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices). The price of carbon was assumed to be \$0, \$10, \$37 or \$50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of Douglas-fir plantations on the Pacific Northwest Coast.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$80.28	Only once	Year 0	
Seedlings[b] (600 seedlings/ac)	$126	Only Once	Year 0	
Burning[a]	$21.24	Every 5 years	Year 10	Final Harvest
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al (2005).

[b]The seedling cost was estimated based on the seedling prices from Source of Oregon Native Forest Tree Seedlings 2004-2005 by elevation (http://egov.oregon.gov/ODF/PRIVATE_FORESTS/docs/2004Catalog.pdf. February 12, 2006).

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Table 45. Total tons of carbon sequestered per acre for Douglas fir plantations in the pacific northwestern United States by site index and real alternative rates of return. (carbon value = $00/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	48.79	48.79	37.93	37.93	37.93	37.93
110	46.39	46.39	46.39	41.79	41.79	41.79
120	45.65	45.65	45.65	45.65	45.65	45.65

[1]Base age 50.

Table 46. Total tons of carbon sequestered per acre for Douglas fir plantations in the pacific northwest United States by site index and real alternative rates of return. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	48.79	48.79	37.93	37.93	37.93	37.93
110	46.39	46.39	46.39	41.79	41.79	41.79
120	45.65	45.65	45.65	45.65	45.65	45.65

[1]Base age 50.

Table 47. Total tons of carbon sequestered per acre for Douglas fir plantations in the pacific northwest United States by site index and real alternative rates of return. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	48.79	48.79	48.79	37.93	37.93	37.93
110	46.39	46.39	46.39	41.79	41.79	41.79
120	45.65	45.65	45.65	45.65	45.65	45.65

[1]Base age 50.

Table 48. Total tons of carbon sequestered per acre for Douglas fir plantations in the pacific northwest United States by site index and real alternative rates of return. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	48.79	48.79	42.48	37.93	37.93	37.93
110	46.39	46.39	46.39	41.79	41.79	41.79
120	45.65	45.65	45.65	45.65	45.65	45.65

[1]Base age 50.

Table 49. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas-fir plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	**25**[2]	**25**	**20**	**20**	**20**	**20**
110	**22**	**22**	**22**	**20**	**20**	**20**
120	**20**	**20**	**20**	**20**	**20**	**20**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

Table 50. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas-fir plantations by site index and real alternative rates of return in the pacific northwest United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	**25**[2]	**25**	**20**	**20**	**20**	**20**
110	**22**	**22**	**22**	**20**	**20**	**20**
120	**20**	**20**	**20**	**20**	**20**	**20**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

Table 51. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas-fir plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	**25**[2]	**25**	**20**	**20**	**20**	**20**
110	**22**	**22**	**22**	**20**	**20**	**20**
120	**20**	**20**	**20**	**20**	**20**	**20**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

Table 52. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas-fir plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	**25**[2]	**25**	**22**	**20**	**20**	**20**
110	**22**	**22**	**22**	**20**	**20**	**20**
120	**20**	**20**	**20**	**20**	**20**	**20**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

Table 53. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the pacific northwest United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$7,383.62	$3,865.51	$1,950.80	$1,092.62	$561.08	$228.42
110	$7,703.90	$4,374.75	$2,452.44	$1,345.93	$722.68	$332.54
120	$8,091.65	$4,850.60	$2,887.14	$1,683.84	$938.26	$471.44

[1]Base age 50.

Table 54. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the pacific northwest United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$7,776.16	$4,177.96	$2,158.28	$1,263.09	$702.01	$345.78
110	$8,088.19	$4,690.49	$2,711.64	$1,546.08	$890.29	$473.82
120	$8,478.95	$5,176.78	$3,161.48	$1,915.16	$1,134.23	$638.46

[1]Base age 50.

Table 55. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the pacific northwest United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$8,835.99	$5,021.57	$8,823.99	$1,723.36	$1,082.53	$662.67
110	$9,125.78	$5,542.78	$3,411.49	$2,086.48	$1,342.82	$855.28
120	$9,524.66	$6,057.45	$3,902.22	$2,539.72	$1,663.33	$1,089.43

[1]Base age 50.

Table 56. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the pacific northwest United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$9,346.28	$5,427.75	$3,110.19	$1,944.98	$1,265.75	$815.24
110	$9,625.36	$5,953.44	$3,748.46	$2,346.67	$1,560.70	$1,038.96
120	$10,028.15	$6,481.48	$4,258.87	$2,840.44	$1,918.08	$1,306.56

[1]Base age 50.

Table 57. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the pacific northwest United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$15,584.62	$5,378.03	$2,497.79	$1,263.34	$612.73	$241.23
110	$17,779.48	$6,486.60	$3,025.83	$1,556.22	$789.21	$351.20
120	$19,998.44	$7,566.56	$3,696.67	$1,946.93	$1,024.64	$497.89

[1]Base age 50.

Table 58. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the pacific northwest United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$16,413.52	$5,812.74	$2,763.44	$1,460.44	$766.64	$365.18
110	$18,666.37	$6,954.76	$3,345.63	$1,787.64	$972.24	$550.41
120	$20,955.65	$8,075.37	$4,047.94	$2,214.39	$1,238.64	$674.29

[1]Base age 50.

Table 59. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the pacific northwest United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$18,650.56	$6,986.44	$18,650.56	$1,992.63	$1,182.19	$699.85
110	$21,060.98	$8,218.78	$4,209.11	$2,412.48	$1,466.43	$903.28
120	$23,540.12	$9,449.15	$4,996.37	$2,936.54	$1,816.45	$1,150.56

[1]Base age 50.

Table 60. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the pacific northwest United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$19,727.66	$7,551.56	$3,837.36	$2,248.87	$1,382.26	$860.99
110	$22,213.94	$8,827.39	$4,624.86	$2,713.33	$1,704.37	$1,087.25
120	$24,784.49	$10,110.60	$5,453.02	$3,284.24	$2,094.65	$1,379.88

[1]Base age 50.

Table 61. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in the pacific northwest United States. (carbon value = $0/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final Harvest MBF	Total Volume MBF
100	2.50%	**25**[3]	-[4]	-	46.34	46.34
	5.00%	**25**	-	-	46.34	46.34
	7.50%	**20**	-	-	32.21	32.21
	10.00%	**20**	-	-	32.21	32.21
	12.50%	**20**	-	-	32.21	32.21
	15.00%	**20**	-	-	32.21	32.21
110	2.50%	**22**	-	-	44.99	44.99
	5.00%	**22**	-	-	44.99	44.99
	7.50%	**22**	-	-	44.99	44.99
	10.00%	**20**	-	-	37.71	37.71
	12.50%	**20**	-	-	37.71	37.71
	15.00%	**20**	-	-	37.71	37.71
120	2.50%	**20**	-	-	37.71	37.71
	5.00%	**20**	-	-	45.04	45.04
	7.50%	**20**	-	-	45.04	45.04
	10.00%	**20**	-	-	45.04	45.04
	12.50%	**20**	-	-	45.04	45.04
	15.00%	**20**	-	-	45.04	45.04

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Indicates no operation conducted.

Table 62. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in the pacific northwest United States. (carbon value = $10/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final Harvest MBF	Total Volume MBF
100	2.50%	**25**[3]	-[4]	-	46.34	46.34
	5.00%	**25**	-	-	46.34	46.34
	7.50%	**20**	-	-	32.21	32.21
	10.00%	**20**	-	-	32.21	32.21
	12.50%	**20**	-	-	32.21	32.21
	15.00%	**20**	-	-	32.21	32.21
110	2.50%	**22**	-	-	44.99	44.99
	5.00%	**22**	-	-	44.99	44.99
	7.50%	**22**	-	-	44.99	44.99
	10.00%	**20**	-	-	37.71	37.71
	12.50%	**20**	-	-	37.71	37.71
	15.00%	**20**	-	-	37.71	37.71
120	2.50%	**20**	-	-	37.71	37.71
	5.00%	**20**	-	-	45.04	45.04
	7.50%	**20**	-	-	45.04	45.04
	10.00%	**20**	-	-	45.04	45.04
	12.50%	**20**	-	-	45.04	45.04
	15.00%	**20**	-	-	45.04	45.04

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Indicates no operation conducted.

Table 63. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in the pacific northwest United States. (carbon value = $37/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final Harvest MBF	Total Volume MBF
100	2.50%	**25**[3]	-[4]	-	46.34	46.34
	5.00%	**25**	-	-	46.34	46.34
	7.50%	**25**	-	-	46.34	46.34
	10.00%	**20**	-	-	32.21	32.21
	12.50%	**20**	-	-	32.21	32.21
	15.00%	**20**	-	-	32.21	32.21
110	2.50%	**22**	-	-	44.99	44.99
	5.00%	**22**	-	-	44.99	44.99
	7.50%	**22**	-	-	44.99	44.99
	10.00%	**20**	-	-	37.71	37.71
	12.50%	**20**	-	-	37.71	37.71
	15.00%	**20**	-	-	37.71	37.71
120	2.50%	**20**	-	-	45.04	45.04
	5.00%	**20**	-	-	45.04	45.04
	7.50%	**20**	-	-	45.04	45.04
	10.00%	**20**	-	-	45.04	45.04
	12.50%	**20**	-	-	45.04	45.04
	15.00%	**20**	-	-	45.04	45.04

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Indicates no operation conducted.

Table 64. **Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in the pacific northwest United States. (carbon value = $50/ton)**

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final Harvest MBF	Total Volume MBF
100	2.50%	**25**[3]	-[4]	-	46.34	46.34
	5.00%	**25**	-	-	46.34	46.34
	7.50%	**22**	-	-	37.58	37.58
	10.00%	**20**	-	-	32.21	32.21
	12.50%	**20**	-	-	32.21	32.21
	15.00%	**20**	-	-	32.21	32.21
110	2.50%	**22**	-	-	44.99	44.99
	5.00%	**22**	-	-	44.99	44.99
	7.50%	**22**	-	-	44.99	44.99
	10.00%	**20**	-	-	37.71	37.71
	12.50%	**20**	-	-	37.71	37.71
	15.00%	**20**	-	-	37.71	37.71
120	2.50%	**20**	-	-	45.04	45.04
	5.00%	**20**	-	-	45.04	45.04
	7.50%	**20**	-	-	45.04	45.04
	10.00%	**20**	-	-	45.04	45.04
	12.50%	**20**	-	-	45.04	45.04
	15.00%	**20**	-	-	45.04	45.04

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Indicates no operation conducted.

Table 65. Financially optimal thinning and final harvest schedules for Douglas fir plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	100	**25**	**25**	0%	**25**	0%	**25**	0%
	110	**22**	**22**	0%	**22**	0%	**22**	0%
	120	**20**	**20**	0%	**20**	0%	**20**	0%
5.00%	100	**25**	**25**	0%	**25**	0%	**25**	0%
	110	**22**	**22**	0%	**22**	0%	**22**	0%
	120	**20**	**20**	0%	**20**	0%	**20**	0%
7.50%	100	**20**	**20**	0%	**20**	0%	**22**	10%
	110	**22**	**22**	0%	**22**	0%	**22**	0%
	120	**20**	**20**	0%	**20**	0%	**20**	0%
10.00%	100	**20**	**20**	0%	**20**	0%	**20**	0%
	110	**20**	**20**	0%	**20**	0%	**20**	0%
	120	**20**	**20**	0%	**20**	0%	**20**	0%
12.50%	100	**20**	**20**	0%	**20**	0%	**20**	0%
	110	**20**	**20**	0%	**20**	0%	**20**	0%
	120	**20**	**20**	0%	**20**	0%	**20**	0%
15.00%	100	**20**	**20**	0%	**20**	0%	**20**	0%
	110	**20**	**20**	0%	**20**	0%	**20**	0%
	120	**20**	**20**	0%	**20**	0%	**20**	0%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3] Number in parentheses indicates the percentage of basal area removed during thinning

[4] <> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 66. The soil expectation value ($/acre) of the financially optimal rotations for Douglas fir plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	100	15,584.62	16,413.52	5%	18,650.56	20%	19,727.66	27%
	110	17,779.48	18,666.37	5%	21,060.98	18%	22,213.94	25%
	120	19,998.44	20,955.65	5%	23,540.12	18%	24,784.49	24%
5.00%	100	5,378.03	5,812.74	8%	6,986.44	30%	7,551.56	40%
	110	6,486.60	6,954.76	7%	8,218.78	27%	8,827.39	36%
	120	7,566.56	8,075.37	7%	9,449.15	25%	10,110.60	34%
7.50%	100	2,497.79	2,763.44	11%	18,650.56	647%	3,837.36	54%
	110	3,025.83	3,345.63	11%	4,209.11	39%	4,624.86	53%
	120	3,696.67	4,047.94	10%	4,996.37	35%	5,453.02	48%
10.00%	100	1,263.34	1,460.44	16%	1,992.63	58%	2,248.87	78%
	110	1,556.22	1,787.64	15%	2,412.48	55%	2,713.33	74%
	120	1,946.93	2,214.39	14%	2,936.54	51%	3,284.24	69%
12.50%	100	612.73	766.64	25%	1,182.19	93%	1,382.26	126%
	110	789.21	972.24	23%	1,466.43	86%	1,704.37	116%
	120	1,024.64	1,238.64	21%	1,816.45	77%	2,094.65	104%
15.00%	100	241.23	365.18	51%	699.85	190%	860.99	257%
	110	351.20	550.41	57%	903.28	157%	1,087.25	210%
	120	497.89	674.29	35%	1,150.56	131%	1,379.88	177%

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>Pacific Northwest- Douglas-fir - Timber Only Rotations (C = $0/ton)</u>

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 49). This optimal management regime will generate the maximum SEV of $15,584.62 (Table 57), with a NPW of $7,383.62 per acre (Table 53). This means that $15,584.62 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $7,383.62 per acre for managing one rotation, or $15,584.62 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 46.34 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 48.79 net tons of carbon per acre during one rotation (Table 45). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 49). This optimal management regime will generate the maximum SEV of $5,378.03 (Table 57), with a NPW of $3,865.51 per acre (Table 53). This financially optimal rotation would produce an estimated 46.34 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 48.79 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 49). This optimal management regime will generate the maximum SEV of $2,497.79 (Table 57), with a NPW of $1,950.80 per acre (Table 53). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 37.93 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 49). This optimal management regime will generate the maximum SEV of $1,263.34 (Table 57), with a NPW of $1,092.62 per acre (Table 53). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 37.93 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 49). This optimal management regime will generate the maximum SEV of $612.93 (Table 57), with a NPW of $561.08 per acre (Table 53). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 37.93 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 49). This optimal management regime will generate the maximum SEV of $241.23 (Table 57), with a NPW of $228.42 per acre (Table 53). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 37.93 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 49). This optimal management regime will generate the maximum SEV of $17,779.48 (Table 57), with a NPW of $7,703.90 per acre (Table 53). This financially optimal rotation would produce an estimated 44.99 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 46.39 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 49). This optimal management regime will generate the maximum SEV of $6,486.60 (Table 57), with a NPW of $4,374.75 per acre (Table 53). This financially optimal rotation would produce an estimated 44.99 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 46.39 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 49). This

optimal management regime will generate the maximum SEV of $3,025.83 (Table 57), with a NPW of $2,452.44 per acre (Table 53). This financially optimal rotation would produce an estimated 44.99 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 46.39 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 49). This optimal management regime will generate the maximum SEV of $1,556.22 (Table 57), with a NPW of $1,345.93 per acre (Table 53). This financially optimal rotation would produce an estimated 37.71 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 41.79 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 49). This optimal management regime will generate the maximum SEV of $789.21 (Table 57), with a NPW of $722.68 per acre (Table 53). This financially optimal rotation would produce an estimated 37.71 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 41.79 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 49). This optimal management regime will generate the maximum SEV of $351.20 (Table 57), with a NPW of $332.54 per acre (Table 53). This financially optimal rotation would

produce an estimated 37.71 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 41.79 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 49). This optimal management regime will generate the maximum SEV of $19,998.44 (Table 57), with a NPW of $8,091.65 per acre (Table 53). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 45.65 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 49). This optimal management regime will generate the maximum SEV of $7,566.56 (Table 57), with a NPW of $4,850.60 per acre (Table 53). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 45.65 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 49). This optimal management regime will generate the maximum SEV of $3,696.67 (Table 57), with a NPW of $2,887.14 per acre (Table 53). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 45.65 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 49). This optimal management regime will generate the maximum SEV of $1,946.93 (Table 57), with a NPW of $1,683.84 per acre (Table 53). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 45.65 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 49). This optimal management regime will generate the maximum SEV of $1,024.64 (Table 57), with a NPW of $938.26 per acre (Table 53). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 45.65 net tons of carbon per acre during one rotation (Table 45).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 49). This optimal management regime will generate the maximum SEV of $497.89 (Table 57), with a NPW of $471.44 per acre (Table 53). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 61), and sequester 45.65 net tons of carbon per acre during one rotation (Table 45).

<u>Pacific Northwest- Douglas-fir - Timber Only Rotations (C = $10/ton)</u>

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 50). This optimal management regime will generate the maximum SEV of $16,413.52 (Table 58), with a NPW of $7,776.16 per acre (Table 54). This means that $16,413.52 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $7,776.16 per acre for managing one rotation, or $16,413.52 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 46.34 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 48.79 net tons of carbon per acre during one rotation (Table 46). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 50). This optimal management regime will generate the maximum SEV of $5,812.74 (Table 58), with a NPW of $4,177.96 per acre (Table 54). This financially optimal rotation would produce an estimated 46.34 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 48.79 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 50). This optimal management regime will generate the maximum SEV of $2,763.44 (Table 58), with a NPW of $2,158.28 per acre (Table 54). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 37.93 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 50). This optimal management regime will generate the maximum SEV of $1,460.44 (Table 58), with a NPW of $1,263.09 per acre (Table 54). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 37.93 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 50). This optimal management regime will generate the maximum SEV of $766.64 (Table 58), with a NPW of $702.01 per acre (Table 54). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 37.93 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 50). This optimal management regime will generate the maximum SEV of $365.18 (Table 58), with a NPW of $345.78 per acre (Table 54). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 37.93 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 50). This optimal management regime will generate the maximum SEV of $18,666.37 (Table 58), with a NPW of $8,088.19 per acre (Table 54). This financially optimal rotation would produce an estimated 44.99 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 46.39 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 50). This optimal management regime will generate the maximum SEV of $6,954.76 (Table 58), with a NPW of $4,690.49 per acre (Table 54). This financially optimal rotation would produce an estimated 44.99 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 46.39 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 50). This

optimal management regime will generate the maximum SEV of $3,345.63 (Table 58), with a NPW of $2,711.64 per acre (Table 54). This financially optimal rotation would produce an estimated 44.99 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 46.39 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 50). This optimal management regime will generate the maximum SEV of $1,787.64 (Table 58), with a NPW of $1,546.08 per acre (Table 54). This financially optimal rotation would produce an estimated 37.71 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 41.79 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 50). This optimal management regime will generate the maximum SEV of $972.24 (Table 58), with a NPW of $890.29 per acre (Table 54). This financially optimal rotation would produce an estimated 37.71 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 41.79 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 50). This optimal management regime will generate the maximum SEV of $550.41 (Table 58), with a NPW of $473.82 per acre (Table 54). This financially optimal rotation would

produce an estimated 37.71 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 41.79 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 50). This optimal management regime will generate the maximum SEV of $20,955.65 (Table 28), with a NPW of $8,478.95 per acre (Table 54). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 45.65 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 50). This optimal management regime will generate the maximum SEV of $8,075.37 (Table 58), with a NPW of $5,176.78 per acre (Table 54). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 45.65 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 50). This optimal management regime will generate the maximum SEV of $4,047.94 (Table 58), with a NPW of $3,161.48 per acre (Table 54). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 45.65 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 50). This optimal management regime will generate the maximum SEV of $2,214.39 (Table 58), with a NPW of $1,915.16 per acre (Table 54). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 45.65 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 50). This optimal management regime will generate the maximum SEV of $1,238.64 (Table 58), with a NPW of $1,134.23 per acre (Table 54). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 45.65 net tons of carbon per acre during one rotation (Table 46).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 50). This optimal management regime will generate the maximum SEV of $674.29 (Table 58), with a NPW of $638.46 per acre (Table 54). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 62), and sequester 45.65 net tons of carbon per acre during one rotation (Table 46).

<u>Pacific Northwest-Douglas-fir - Timber Only Rotations (C = $37/ton)</u>

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 51). This optimal management regime will generate the maximum SEV of $18,650.56 (Table 59), with a NPW of $8,835.99 per acre (Table 55). This means that $18,650.56 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $8,835.99 per acre for managing one rotation, or $18,650.56 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 46.34 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 48.79 net tons of carbon per acre during one rotation (Table 47). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 51). This optimal management regime will generate the maximum SEV of $6,986.44 (Table 59), with a NPW of $5,021.57 per acre (Table 55). This financially optimal rotation would produce an estimated 46.34 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 48.79 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 51). This optimal management regime will generate the maximum SEV of $3,480.70 (Table 59), with a NPW of $2,718.48 per acre (Table 55). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 37.93 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 51). This optimal management regime will generate the maximum SEV of $1,992.63 (Table 59), with a NPW of $1,723.36 per acre (Table 55). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 37.93 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 51). This optimal management regime will generate the maximum SEV of $1,182.19 (Table 59), with a NPW of $1,082.53 per acre (Table 55). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 37.93 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 51). This optimal management regime will generate the maximum SEV of $699.85 (Table 59), with a NPW of $662.67 per acre (Table 55). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 37.93 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 51). This optimal management regime will generate the maximum SEV of $21,060.98 (Table 59), with a NPW of $9,125.78 per acre (Table 55). This financially optimal rotation would produce an estimated 44.99 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 46.39 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 51). This optimal management regime will generate the maximum SEV of $8,218.78 (Table 59), with a NPW of $5,542.78 per acre (Table 55). This financially optimal rotation would produce an estimated 44.99 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 46.39 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 51). This

optimal management regime will generate the maximum SEV of $4,209.11 (Table 59), with a NPW of $3,411.49 per acre (Table 55). This financially optimal rotation would produce an estimated 44.99 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 46.39 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 51). This optimal management regime will generate the maximum SEV of $2,412.48 (Table 59), with a NPW of $2,086.48 per acre (Table 55). This financially optimal rotation would produce an estimated 37.71 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 41.79 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 51). This optimal management regime will generate the maximum SEV of $1,466.43 (Table 59), with a NPW of $1,342.82 per acre (Table 55). This financially optimal rotation would produce an estimated 37.71 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 41.79 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 51). This optimal management regime will generate the maximum SEV of $903.28 (Table 59), with a NPW of $855.28 per acre (Table 55). This financially optimal rotation would

produce an estimated 37.71 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 41.79 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 51). This optimal management regime will generate the maximum SEV of $23,540.12 (Table 59), with a NPW of $9,524.66 per acre (Table 55). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 45.65 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 51). This optimal management regime will generate the maximum SEV of $9,449.15 (Table 59), with a NPW of $6,057.45 per acre (Table 55). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 45.65 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 51). This optimal management regime will generate the maximum SEV of $4,996.37 (Table 59), with a NPW of $3,902.22 per acre (Table 55). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 45.65 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 51). This optimal management regime will generate the maximum SEV of $2,936.54 (Table 59), with a NPW of $2,539.72 per acre (Table 55). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 45.65 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 51). This optimal management regime will generate the maximum SEV of $1,816.45 (Table 59), with a NPW of $1,663.33 per acre (Table 55). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 45.65 net tons of carbon per acre during one rotation (Table 47).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 51). This optimal management regime will generate the maximum SEV of $1,150.56 (Table 59), with a NPW of $1,089.43 per acre (Table 55). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 63), and sequester 45.65 net tons of carbon per acre during one rotation (Table 47).

Pacific Northwest- Douglas-fir - Timber Only Rotations (C = $50/ton)

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 52). This optimal management regime will generate the maximum SEV of $19,727.66 (Table 60), with a NPW of $9,346.28 per acre (Table 56). This means that $19,727.66 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $9,346.28 per acre for managing one rotation, or $19,727.66 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 46.34 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 48.79 net tons of carbon per acre during one rotation (Table 48). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 52). This optimal management regime will generate the maximum SEV of $7,551.56 (Table 60), with a NPW of $5,427.75 per acre (Table 56). This financially optimal rotation would produce an estimated 46.34 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 48.79 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 52). This optimal management regime will generate the maximum SEV of $3,837.36 (Table 60), with a NPW of $3,110.19 per acre (Table 56). This financially optimal rotation would produce an estimated 37.58 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 42.48 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 52). This optimal management regime will generate the maximum SEV of $2,248.87 (Table 60), with a NPW of $1,944.98 per acre (Table 56). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 37.93 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 52). This optimal management regime will generate the maximum SEV of $1,382.26 (Table 60), with a NPW of $1,265.75 per acre (Table 56). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 37.93 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 52). This optimal management regime will generate the maximum SEV of $860.99 (Table 60), with a NPW of $815.24 per acre (Table 56). This financially optimal rotation would produce an estimated 32.21 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 37.93 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 52). This optimal management regime will generate the maximum SEV of $22,213.94 (Table 60), with a NPW of $9,625.36 per acre (Table 56). This financially optimal rotation would produce an estimated 44.99 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 46.39 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 52). This optimal management regime will generate the maximum SEV of $8,827.39 (Table 60), with a NPW of $5,953.44 per acre (Table 56). This financially optimal rotation would produce an estimated 44.99 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 46.39 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 52). This

optimal management regime will generate the maximum SEV of $4,624.86 (Table 60), with a NPW of $3,748.46 per acre (Table 56). This financially optimal rotation would produce an estimated 44.99 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 46.39 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 52). This optimal management regime will generate the maximum SEV of $2,713.33 (Table 60), with a NPW of $2,346.67 per acre (Table 56). This financially optimal rotation would produce an estimated 37.71 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 41.79 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 52). This optimal management regime will generate the maximum SEV of $1,704.37 (Table 60), with a NPW of $1,560.70 per acre (Table 56). This financially optimal rotation would produce an estimated 37.71 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 41.79 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 52). This optimal management regime will generate the maximum SEV of $1,087.25 (Table 60), with a NPW of $1,038.96 per acre (Table 56). This financially optimal rotation would

produce an estimated 37.71 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 41.79 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 52). This optimal management regime will generate the maximum SEV of $24,784.49 (Table 60), with a NPW of $10,028.15 per acre (Table 56). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 45.65 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 52). This optimal management regime will generate the maximum SEV of $10,110.60 (Table 60), with a NPW of $6,481.48 per acre (Table 56). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 45.65 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 52). This optimal management regime will generate the maximum SEV of $5,453.02 (Table 60), with a NPW of $4,258.87 per acre (Table 56). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 45.65 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 52). This optimal management regime will generate the maximum SEV of $3,284.24 (Table 60), with a NPW of $2,840.44 per acre (Table 56). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 45.65 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 52). This optimal management regime will generate the maximum SEV of $2,094.65 (Table 60), with a NPW of $1,918.08 per acre (Table 56). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 45.65 net tons of carbon per acre during one rotation (Table 48).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 52). This optimal management regime will generate the maximum SEV of $1,379.88 (Table 60), with a NPW of $1,306.56 per acre (Table 56). This financially optimal rotation would produce an estimated 45.04 MBF of sawlogs per acre from the final harvest (Table 64), and sequester 45.65 net tons of carbon per acre during one rotation (Table 48).

Species Douglas-fir Region Southern-Central Oregon, Northeast California

Site indices 100, 110 and 120 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 6.0-in. inside bark top diameter for trees with a minimum of 9 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 9-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 15 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.187943262 and 0.709219858, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Grier and Logan (1977) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Y = \exp(-2.656 + 2.530 \ln X)$$

where:

Y = component dry weight (kg)

X = stem diameter at breast height (cm)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.6% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $331/mbf (Scribner) (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices) and pulpwood price was assumed to be $0/cord (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of Douglas-fir plantations in South-Central Oregon and Northeastern California.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$80.28	Only once	Year 0	
Seedlings[b] (600 seedlings/ac)	$162	Only Once	Year 0	
Burning[a]	$21.24	Every 5 years	Year 10	Final Harvest
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al (2005).

[b]The seedling cost was estimated based on the seedling prices from Source of Oregon Native Forest Tree Seedlings 2004-2005 by elevation (http://egov.oregon.gov/ODF/PRIVATE_FORESTS/docs/2004Catalog.pdf. February 12, 2006).

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Table 67. Total tons of carbon sequestered per acre for Douglas fir plantations in south central Oregon by site index and real alternative rates of return. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	32.53	24.28	22.83	20.08	20.08	20.08
110	28.48	25.66	22.32	21.94	19.93	19.43
120	26.68	25.80	24.72	24.72	24.72	24.72

[1]Base age 50.

Table 68. Total tons of carbon sequestered per acre for Douglas fir plantations in south central Oregon by site index and real alternative rates of return. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	32.53	24.28	24.28	20.08	20.08	20.08
110	28.48	25.66	22.32	21.94	19.93	19.93
120	26.68	25.80	24.72	24.72	24.72	24.72

[1]Base age 50.

Table 69. Total tons of carbon sequestered per acre for Douglas fir plantations in south central Oregon by site index and real alternative rates of return. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	32.53	24.95	24.28	20.08	20.08	20.08
110	30.71	25.66	22.32	22.32	19.93	19.93
120	26.68	25.80	24.72	24.72	24.72	24.72

[1]Base age 50.

Table 70. Total tons of carbon sequestered per acre for Douglas fir plantations in south central Oregon by site index and real alternative rates of return. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	32.53	24.95	24.28	22.83	20.08	20.08
110	30.71	25.66	24.93	22.65	21.94	19.93
120	26.68	25.80	24.72	24.72	24.72	24.72

[1]Base age 50.

Table 71. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in south central Oregon. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	26-33-**49**[2] (20%)[3]	26-**34** (20%)	<26-**32>**[4] (20%)	**<29>**	**<29>**	**<29>**
110	25-34-**41** (20%)	25-**35** (20%)	26-**31** (20%)	<25-**30**> **(20%)**	**<28>**	**<27>**
120	20-**34** (30%)	21-**33** (25%)	17-**29** (30%)	<17-**29**> (30%)	<17-**29>** (30%)	<17-**29>** (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 72. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in south central Oregon. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	26-33-**49**[2] (20%)[3]	26-**34** (20%)	26-**34** (20%)	**<29>**[4]	**<29>**	**<29>**
110	25-34-**41** (20%)	25-**35** (20%)	26-**31** (20%)	<25-**30**> (20%)	**<28>**	**<28>**
120	20-**34** (30%)	21-**33** (25%)	17-**29** (30%)	<17-**29**> (30%)	<17-**29**> (30%)	<17-**29**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 73. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in south central Oregon. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	26-33-**49**[2] (20%)[3]	26-**35** (20%)	26-**34** (20%)	**29**	**<29>**[4]	**<29>**
110	25-34-**45** (20%)	25-**35** (20%)	26-**31** (20%)	26-**31** (20%)	**<28>**	**<28>**
120	20-**34** (30%)	21-**33** (25%)	17-**29** (30%)	17-**29** (30%)	17-**29** (30%)	<17-**29>** (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 74. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in south central Oregon. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	26-33-**49**[2] (20%)[3]	26-**35** (20%)	26-**34** (20%)	26-**32** (20%)	**29**	**<29>**[4]
110	25-34-**45** (20%)	25-**35** (20%)	25-**34** (20%)	25-**31** (20%)	25-**30** (20%)	**<28>**
120	20-**34** (30%)	21-**33** (25%)	17-**29** (30%)	17-**29** (30%)	17-**29** (30%)	<17-**29>** (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 75. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the south central Oregon. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$2,056.44	$458.43	-$29.32	-$221.98	-$314.81	-$361.20
110	$2,134.22	$581.68	$32.57	-$196.44	-$299.09	-$350.33
120	$2,136.09	$697.01	$95.87	-$154.91	-$279.86	-$342.72

[1]Base age 50.

Table 76. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the south central Oregon. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$2,295.78	$606.18	$83.80	-$138.19	-$247.75	-$306.96
110	$2,355.03	$738.37	$147.02	-$106.39	-$227.88	-$293.16
120	$2,345.01	$855.33	$215.53	-$59.89	-$203.42	-$280.35

[1]Base age 50.

Table 77. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the south central Oregon. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$2,942.01	$1,016.53	$391.04	$88.03	-$66.69	-$160.51
110	$3,104.48	$1,161.46	$456.04	$138.14	-$35.62	-$135.83
120	$2,909.09	$1,282.81	$538.63	$196.63	$2.96	-$111.93

[1]Base age 50.

Table 78. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the south central Oregon. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$3,253.16	$1,211.87	$538.98	$200.28	$20.49	-$89.99
110	$3,408.02	$1,365.16	$620.26	$256.39	$58.02	-$60.09
120	$3,180.69	$1,488.64	$694.19	$320.15	$102.32	-$30.84

[1]Base age 50.

Table 79. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in south central Oregon. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$2,900.24	$559.94	-$32.28	-$235.47	-$324.28	-$366.74
110	$3,306.22	$703.07	$36.15	-$207.24	-$309.25	-$357.47
120	$3,691.65	$860.88	$108.23	-$164.32	-$288.28	-$347.98

[1]Base age 50.

Table 80. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in south central Oregon. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$3,237.79	$740.41	$91.04	-$146.59	-$255.20	-$311.67
110	$3,648.30	$892.47	$163.15	-$112.24	-$235.62	-$298.34
120	$4,052.70	$1,056.43	$243.33	-$63.54	-$209.54	-$284.65

[1]Base age 50.

Table 81. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in south central Oregon. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$4,149.19	$1,228.66	$424.84	$93.39	-$68.69	-$162.97
110	$4,573.11	$1,403.84	$506.06	$145.01	-$36.83	-$138.24
120	$5,027.56	$1,584.42	$608.08	$208.59	$3.04	-$113.65

[1]Base age 50.

Table 82. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in south central Oregon. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$4,588.01	$1,464.78	$585.56	$209.29	$21.11	-$91.37
110	$5,020.25	$1,650.06	$673.88	$269.14	$59.56	-$61.15
120	$5,496.94	$1,838.63	$783.70	$339.61	$105.40	-$31.31

[1]Base age 50.

Table 83. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in south central Oregon. (carbon value = $0/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final Harvest MBF	Total Volume MBF
100	2.50%	26-33-**49**[3] (20%)[4]	0	2.87	22.28	25.15
	5.00%	26-**34** (20%)	0	-	15.2	15.2
	7.50%	26-**32** (20%)	0	-	13.22	13.22
	10.00%	**29**	-[5]	-	10.46	10.46
	12.50%	**29**	-	-	10.46	10.46
	15.00%	**29**	-	-	10.46	10.46
110	2.50%	25-34-**41** (20%)	0	3.39	18.63	22.02
	5.00%	25-**35** (20%)	0	-	18.13	18.13
	7.50%	26-**31** (20%)	0	-	14.16	14.16
	10.00%	25-**30 (**20**%)**	0	-	13.01	13.01
	12.50%	**28**	-	-	10.67	10.67
	15.00%	**27**	-	-	9.45	9.45
120	2.50%	20-**34** (30%)	0	-	19.12	19.12
	5.00%	21-**33** (25%)	0	-	18.25	18.25
	7.50%	17-**29** (30%)	0	-	13.83	13.83
	10.00%	17-**29** (30%)	0	-	13.83	13.83
	12.50%	17-**29** (30%)	0	-	13.83	13.83
	15.00%	17-**29** (30%)	0	-	13.83	13.83

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 84. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in south central Oregon. (carbon value = $10/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final Harvest MBF	Total Volume MBF
100	2.50%	26-33-**49**[3] (20%)[4]	0	2.87	22.28	25.15
	5.00%	26-**34** (20%)	0	0	22.27	15.2
	7.50%	26-**34** (20%)	0	-	15.2	15.2
	10.00%	**29**	-[5]	-	10.46	10.46
	12.50%	**29**	-	-	10.46	10.46
	15.00%	**29**	-	-	10.46	10.46
110	2.50%	25-34-**41** (20%)	0	3.39	18.63	22.02
	5.00%	25-**35** (20%)	0	-	18.13	18.13
	7.50%	26-**31** (20%)	0	-	14.16	14.16
	10.00%	25-**30** (20%)	0	-	13.01	13.01
	12.50%	**28**	-	-	10.67	10.67
	15.00%	**28**	-	-	10.67	10.67
120	2.50%	20-**34** (30%)	0	-	19.12	19.12
	5.00%	21-**33** (25%)	0	-	18.25	18.25
	7.50%	17-**29** (30%)	0	-	13.83	13.83
	10.00%	17-**29** (30%)	0	-	13.83	13.83
	12.50%	17-**29** (30%)	0	-	13.83	13.83
	15.00%	17-**29** (30%)	0	-	13.83	13.83

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 85. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in south central Oregon. (carbon value = $37/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final Harvest MBF	Total Volume MBF
100	2.50%	26-33-**49**[3] (20%)[4]	0	2.87	22.28	25.15
	5.00%	26-**35** (20%)	0	-	16.04	16.04
	7.50%	26-**34** (20%)	0	-	15.2	15.2
	10.00%	**29**	-[5]	-	10.46	10.46
	12.50%	**29**	-	-	10.46	10.46
	15.00%	**29**	-	-	10.46	10.46
110	2.50%	25-34-**45** (20%)	0	3.39	21.47	24.86
	5.00%	25-**35** (20%)	0	-	18.13	18.13
	7.50%	26-**31** (20%)	0	-	14.16	14.16
	10.00%	26-**31** (20%)	0	-	14.16	14.16
	12.50%	**28**	-	-	10.67	10.67
	15.00%	**28**	-	-	10.67	10.67
120	2.50%	20-**34** (30%)	0	-	19.12	19.12
	5.00%	21-**33** (25%)	0	-	18.25	18.25
	7.50%	17-**29** (30%)	0	-	13.83	13.83
	10.00%	17-**29** (30%)	0	-	13.83	13.83
	12.50%	17-**29** (30%)	0	-	13.83	13.83
	15.00%	17-**29** (30%)	0	-	13.83	13.83

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 86. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in south central Oregon. (carbon value = $50/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final Harvest MBF	Total Volume MBF
100	2.50%	26-33-**49**[3] (20%)[4]	0	28.69	22.27	50.96
	5.00%	26-**35** (20%)	0	-	16.04	16.04
	7.50%	26-**34** (20%)	0	-	15.2	15.2
	10.00%	26-**32** (20%)	0	-	13.22	13.22
	12.50%	**29**	-[5]	-	10.46	10.46
	15.00%	**29**	-	-	10.46	10.46
110	2.50%	25-34-**45** (20%)	0	33.93	21.47	55.4
	5.00%	25-**35** (20%)	0	-	18.13	18.13
	7.50%	25-**34** (20%)	0	-	17.1	17.1
	10.00%	25-**31** (20%)	0	-	14.13	14.13
	12.50%	25-**30** (20%)	0	-	13.01	13.01
	15.00%	**28**	-	-	10.67	10.67
120	2.50%	20-**34** (30%)	0	-	19.12	19.12
	5.00%	21-**33** (25%)	0	-	18.25	18.25
	7.50%	17-**29** (30%)	0	-	13.83	13.83
	10.00%	17-**29** (30%)	0	-	13.83	13.83
	12.50%	17-**29** (30%)	0	-	13.83	13.83
	15.00%	17-**29** (30%)	0	-	13.83	13.83

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 87. Financially optimal thinning and final harvest schedules for Douglas fir plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	100	26-33-**49**[2] (20%)[3]	26-33-**49** (20%)	0%	26-33-**49** (20%)	0%	26-33-**49** (20%)	0%
	110	25-34-**41** (20%)	25-34-**41** (20%)	0%	25-34-**45** (20%)	10%	25-34-**45** (20%)	10%
	120	20-**34** (30%)	20-**34** (30%)	0%	20-**34** (30%)	0%	20-**34** (30%)	0%
5.00%	100	26-**34** (20%)	26-**34** (20%)	0%	26-**35** (20%)	3%	26-**35** (20%)	3%
	110	25-**35** (20%)	25-**35** (20%)	0%	25-**35** (20%)	0%	25-**35** (20%)	0%
	120	21-**33** (25%)	21-**33** (25%)	0%	21-**33** (25%)	0%	21-**33** (25%)	0%
7.50%	100	<26-**32**>[4] (20%)	26-**34** (20%)	6%	26-**34** (20%)	6%	26-**34** (20%)	6%
	110	26-**31** (20%)	26-**31** (20%)	0%	26-**31** (20%)	0%	25-**34** (20%)	10%
	120	17-**29** (30%)	17-**29** (30%)	0%	17-**29** (30%)	0%	17-**29** (30%)	0%
10.00%	100	**<29>**	**<29>**	0%	**29**	0%	26-**32** (20%)	10%
	110	<25-**30**> (20%)	<25-**30**> (20%)	0%	26-**31** (20%)	3%	25-**31** (20%)	3%
	120	<17-**29**> (30%)	<17-**29**> (30%)	0%	17-**29** (30%)	0%	17-**29** (30%)	0%
12.50%	100	**<29>**	**<29>**	0%	**<29>**	0%	**29**	0%
	110	**<28>**	**<28>**	0%	**<28>**	0%	25-**30** (20%)	7%
	120	<17-**29**> (30%)	<17-**29**> (30%)	0%	17-**29** (30%)	0%	17-**29** (30%)	34%
15.00%	100	**<29>**	**<29>**	0%	**<29>**	0%	**<29>**	0%
	110	**<27>**	**<28>**	4%	**<28>**	4%	**<28>**	4%
	120	<17-**29**> (30%)	<17-**29**> (30%)	0%	<17-**29**> (30%)	0%	<17-**29**> (30%)	0%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3] Number in parentheses indicates the percentage of basal area removed during thinning

[4] <> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 88. The soil expectation value ($/acre) of the financially optimal rotations for Douglas fir plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	100	2,900.24	3,237.79	12%	4,149.19	43%	4,588.01	58%
	110	3,306.22	3,648.30	10%	4,573.11	38%	5,020.25	52%
	120	3,691.65	4,052.70	10%	5,027.56	36%	5,496.94	49%
5.00%	100	559.94	740.41	32%	1,228.66	119%	1,464.78	162%
	110	703.07	892.47	27%	1,403.84	100%	1,650.06	135%
	120	860.88	1,056.43	23%	1,584.42	84%	1,838.63	114%
7.50%	100	-32.28	91.04		424.84		585.56	
	110	36.15	163.15		506.06		673.88	
	120	108.23	243.33		608.08		783.70	
10.00%	100	-235.47	-146.59		93.39		209.29	
	110	-207.24	-112.24		145.01		269.14	
	120	-164.32	-63.54		208.59		339.61	
12.50%	100	-324.28	-255.20		-68.69		21.11	
	110	-309.25	-235.62		-36.83		59.56	
	120	-288.28	-209.54		3.04		105.40	
15.00%	100	-366.74	-311.67		-162.97		-91.37	
	110	-357.47	-298.34		-138.24		-61.15	
	120	-347.98	-284.65		-113.65		-31.31	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>South Central Oregon- Douglas-fir - Timber Only Rotations (C = $0/ton)</u>

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 33 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 71). This optimal management regime will generate the maximum SEV of $2,900.24 (Table 79), with a NPW of $2,056.44 per acre (Table 75). This means that $2,900.24 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,056.44 per acre for managing one rotation, or $2,900.24 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 25.15 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 32.53 net tons of carbon per acre during one rotation (Table 67). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 34 (Table 71). This optimal management regime will generate the maximum SEV of $559.94 (Table 79), with a NPW of $458.43 per acre (Table 75). This financially optimal rotation would

produce an estimated 15.20 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 24.28 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 32 (Table 71). This optimal management regime will generate the maximum SEV of -$32.28 (Table 79), with a NPW of -$29.32 per acre (Table 75). This financially optimal rotation would produce an estimated 13.22 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 22.83 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 71). This optimal management regime will generate the maximum SEV of -$235.47 (Table 79), with a NPW of -$221.98 per acre (Table 75). This financially optimal rotation would produce an estimated 10.46 MBF of sawlogs per acre from the final harvest (Table 83), and sequester 20.08 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 71). This optimal management regime will generate the maximum SEV of -$324.28 (Table 79), with a NPW of -$314.81 per acre (Table 75). This financially optimal rotation would

produce an estimated 10.46 MBF of sawlogs per acre from the final harvest (Table 83), and sequester 20.08 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 71). This optimal management regime will generate the maximum SEV of -$366.74 (Table 79), with a NPW of -$361.20 per acre (Table 75). This financially optimal rotation would produce an estimated 10.46 MBF of sawlogs per acre from the final harvest (Table 83), and sequester 20.08 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 34 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 41 (Table 71). This optimal management regime will generate the maximum SEV of $3,306.22 (Table 79), with a NPW of $2,134.22 per acre (Table 75). This financially optimal rotation would produce an estimated 22.02 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 28.48 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 35 (Table 71). This optimal management regime will generate the maximum SEV of $703.07 (Table 79),

with a NPW of $581.68 per acre (Table 75). This financially optimal rotation would produce an estimated 18.13 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 25.66 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 31 (Table 71). This optimal management regime will generate the maximum SEV of $36.15 (Table 79), with a NPW of $32.57 per acre (Table 75). This financially optimal rotation would produce an estimated 14.16 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 22.32 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 30 (Table 71). This optimal management regime will generate the maximum SEV of -$207.24 (Table 79), with a NPW of -$196.44 per acre (Table 75). This financially optimal rotation would produce an estimated 13.01 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 21.94 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 28 (Table 71). This optimal management regime will generate the maximum SEV of -$309.25 (Table 79), with a NPW of -$299.09 per acre (Table 75). This financially optimal rotation would produce an estimated 10.67 MBF of sawlogs per acre from the final harvest (Table 83), and sequester 19.93 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 71). This optimal management regime will generate the maximum SEV of -$357.47 (Table 79), with a NPW of -$350.33 per acre (Table 75). This financially optimal rotation would produce an estimated 9.45 MBF of sawlogs per acre from the final harvest (Table 83), and sequester 19.43 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 34 (Table 71). This optimal management regime will generate the maximum SEV of $3,691.65 (Table 79), with a NPW of $2,136.09 per acre (Table 75). This financially optimal rotation would produce an estimated 19.12 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 26.68 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 71). This optimal management regime will generate the maximum SEV of $860.88 (Table 79), with a NPW of $697.01 per acre (Table 75). This financially optimal rotation would produce an estimated 18.25 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 25.80 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 71). This optimal management regime will generate the maximum SEV of $108.23 (Table 79), with a NPW of $95.87 per acre (Table 75). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 24.72 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 71). This optimal management regime will generate the maximum SEV of -$164.32 (Table 79), with a NPW of -$154.91 per acre (Table 75). This financially optimal rotation would

produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 24.72 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 71). This optimal management regime will generate the maximum SEV of -$288.28 (Table 79), with a NPW of -$279.86 per acre (Table 75). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 24.72 net tons of carbon per acre during one rotation (Table 67).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 71). This optimal management regime will generate the maximum SEV of -$347.98 (Table 79), with a NPW of -$342.72 per acre (Table 75). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 24.72 net tons of carbon per acre during one rotation (Table 67).

South Central Oregon- Douglas-fir - Timber Only Rotations (C = $10/ton)

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 33 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 72). This optimal management regime will generate the maximum SEV of $3,237.79 (Table 80), with a NPW of $2,295.78 per acre (Table 76). This means that $3,237.79 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,295.78 per acre for managing one rotation, or $3,237.79 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 25.15 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 32.53 net tons of carbon per acre during one rotation (Table 68). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 34 (Table 72). This optimal management regime will generate the maximum SEV of $740.41 (Table 80), with a NPW of $606.18 per acre (Table 76). This financially optimal rotation would

produce an estimated 15.20 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 24.28 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 34 (Table 72). This optimal management regime will generate the maximum SEV of $91.04 (Table 80), with a NPW of $83.80 per acre (Table 76). This financially optimal rotation would produce an estimated 15.20 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 24.28 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 72). This optimal management regime will generate the maximum SEV of -$146.59 (Table 80), with a NPW of -$138.19 per acre (Table 76). This financially optimal rotation would produce an estimated 10.46 MBF of sawlogs per acre from the final harvest (Table 84), and sequester 20.08 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 72). This optimal management regime will generate the maximum SEV of -$255.20 (Table 80), with a NPW of -$247.75 per acre (Table 76). This financially optimal rotation would

produce an estimated 10.46 MBF of sawlogs per acre from the final harvest (Table 84), and sequester 20.08 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 72). This optimal management regime will generate the maximum SEV of -$311.67 (Table 80), with a NPW of -$306.96 per acre (Table 76). This financially optimal rotation would produce an estimated 10.46 MBF of sawlogs per acre from the final harvest (Table 84), and sequester 20.08 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 34 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 41 (Table 72). This optimal management regime will generate the maximum SEV of $3,648.30 (Table 80), with a NPW of $2,355.03 per acre (Table 76). This financially optimal rotation would produce an estimated 22.02 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 28.48 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 35 (Table 72). This optimal management regime will generate the maximum SEV of $892.47 (Table 80),

with a NPW of $738.37 per acre (Table 76). This financially optimal rotation would produce an estimated 18.13 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 25.66 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 31 (Table 72). This optimal management regime will generate the maximum SEV of $163.15 (Table 80), with a NPW of $147.02 per acre (Table 76). This financially optimal rotation would produce an estimated 14.16 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 22.32 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 30 (Table 72). This optimal management regime will generate the maximum SEV of -$112.24 (Table 80), with a NPW of -$106.39 per acre (Table 76). This financially optimal rotation would produce an estimated 13.01 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 21.94 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 28 (Table 72). This optimal management regime will generate the maximum SEV of -$235.62 (Table 80), with a NPW of -$227.88 per acre (Table 76). This financially optimal rotation would produce an estimated 10.67 MBF of sawlogs per acre from the final harvest (Table 84), and sequester 19.93 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 28 (Table 72). This optimal management regime will generate the maximum SEV of -$298.34 (Table 80), with a NPW of -$293.16 per acre (Table 76). This financially optimal rotation would produce an estimated 10.67 MBF of sawlogs per acre from the final harvest (Table 84), and sequester 19.93 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 34 (Table 72). This optimal management regime will generate the maximum SEV of $4,052.70 (Table 80), with a NPW of $2,345.01 per acre (Table 76). This financially optimal rotation would produce an estimated 19.12 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 26.68 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 72). This optimal management regime will generate the maximum SEV of $1,056.43 (Table 80), with a NPW of $855.33 per acre (Table 76). This financially optimal rotation would produce an estimated 18.25 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 25.80 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 72). This optimal management regime will generate the maximum SEV of $243.33 (Table 80), with a NPW of $215.53 per acre (Table 76). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 24.72 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 72). This optimal management regime will generate the maximum SEV of -$63.54 (Table 80), with a NPW of -$59.89 per acre (Table 76). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 24.72 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 72). This optimal management regime will generate the maximum SEV of -$209.54 (Table 80), with a NPW of -$203.42 per acre (Table 76). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 24.72 net tons of carbon per acre during one rotation (Table 68).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 72). This optimal management regime will generate the maximum SEV of -$284.65 (Table 80), with a NPW of -$280.35 per acre (Table 76). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 24.72 net tons of carbon per acre during one rotation (Table 68).

<u>South Central Oregon-Douglas-fir - Timber Only Rotations (C = $37/ton)</u>

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 33 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 73). This optimal management regime will generate the maximum SEV of $4,149.19 (Table 81), with a NPW of $2,942.01 per acre (Table 77). This means that $4,149.19 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,942.01 per acre for managing one rotation, or $4,149.19 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 25.15 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 32.53 net tons of carbon per acre during one rotation (Table 69). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 35 (Table 73). This optimal management regime will generate the maximum SEV of $1,228.66 (Table 81), with a NPW of $1,016.53 per acre (Table 77). This financially optimal rotation would

produce an estimated 16.04 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 24.95 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 34 (Table 73). This optimal management regime will generate the maximum SEV of $424.84 (Table 81), with a NPW of $391.04 per acre (Table 77). This financially optimal rotation would produce an estimated 15.20 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 24.28 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 73). This optimal management regime will generate the maximum SEV of $93.39 (Table 81), with a NPW of $88.03 per acre (Table 77). This financially optimal rotation would produce an estimated 10.46 MBF of sawlogs per acre from the final harvest (Table 85), and sequester 20.08 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 73). This optimal management regime will generate the maximum SEV of -$68.69 (Table 81), with

a NPW of -$66.69 per acre (Table 77). This financially optimal rotation would produce an estimated 10.46 MBF of sawlogs per acre from the final harvest (Table 85), and sequester 20.08 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 73). This optimal management regime will generate the maximum SEV of -$162.97 (Table 81), with a NPW of -$160.51 per acre (Table 77). This financially optimal rotation would produce an estimated 10.46 MBF of sawlogs per acre from the final harvest (Table 85), and sequester 20.08 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 34 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 45 (Table 73). This optimal management regime will generate the maximum SEV of $4,573.11 (Table 81), with a NPW of $3,104.48 per acre (Table 77). This financially optimal rotation would produce an estimated 24.86 MBF of sawlogs per acre from the final harvest (Table 85), and sequester 30.71 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 35 (Table 73). This

optimal management regime will generate the maximum SEV of $1,403.84 (Table 81), with a NPW of $1,161.46 per acre (Table 77). This financially optimal rotation would produce an estimated 18.13 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 25.66 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 31 (Table 73). This optimal management regime will generate the maximum SEV of $506.06 (Table 81), with a NPW of $456.04 per acre (Table 77). This financially optimal rotation would produce an estimated 14.16 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 22.32 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 31 (Table 73). This optimal management regime will generate the maximum SEV of $145.01 (Table 81), with a NPW of $138.14 per acre (Table 77). This financially optimal rotation would produce an estimated 14.16 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 22.32 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 28 (Table 73). This optimal management regime will generate the maximum SEV of -$36.83 (Table 81), with a NPW of -$35.62 per acre (Table 77). This financially optimal rotation would produce an estimated 10.67 MBF of sawlogs per acre from the final harvest (Table 85), and sequester 19.93 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 28 (Table 73). This optimal management regime will generate the maximum SEV of -$138.24 (Table 81), with a NPW of -$135.83 per acre (Table 77). This financially optimal rotation would produce an estimated 10.67 MBF of sawlogs per acre from the final harvest (Table 85), and sequester 19.93 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 34 (Table 73). This optimal management regime will generate the maximum SEV of $5,027.56 (Table 81), with a NPW of $2,909.09 per acre (Table 77). This financially optimal rotation would produce an estimated 19.12 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 26.68 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 73). This optimal management regime will generate the maximum SEV of $1,584.42 (Table 81), with a NPW of $1,282.81 per acre (Table 77). This financially optimal rotation would produce an estimated 18.25 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 25.80 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 73). This optimal management regime will generate the maximum SEV of $608.08 (Table 81), with a NPW of $538.63 per acre (Table 77). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 24.72 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 73). This optimal management regime will generate the maximum SEV of $208.59 (Table 81),

with a NPW of $196.63 per acre (Table 77). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 24.72 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 73). This optimal management regime will generate the maximum SEV of $3.04 (Table 81), with a NPW of $2.96 per acre (Table 77). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 24.72 net tons of carbon per acre during one rotation (Table 69).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 73). This optimal management regime will generate the maximum SEV of -$113.65 (Table 81), with a NPW of -$111.93 per acre (Table 77). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 24.72 net tons of carbon per acre during one rotation (Table 69).

South Central Oregon- Douglas-fir - Timber Only Rotations (C = $50/ton)

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 33 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 74). This optimal management regime will generate the maximum SEV of $4,588.01 (Table 82), with a NPW of $3,253.16 per acre (Table 78). This means that $4,588.01 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $3,253.16 per acre for managing one rotation, or $4,588.01 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 25.15 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 32.53 net tons of carbon per acre during one rotation (Table 70). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 35 (Table 74). This optimal management regime will generate the maximum SEV of $1,464.78 (Table 82), with a NPW of $1,211.87 per acre (Table 78). This financially optimal rotation would

produce an estimated 16.04 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 24.95 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 34 (Table 74). This optimal management regime will generate the maximum SEV of $585.56 (Table 82), with a NPW of $538.98 per acre (Table 78). This financially optimal rotation would produce an estimated 15.20 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 24.28 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 32 (Table 74). This optimal management regime will generate the maximum SEV of $209.29 (Table 82), with a NPW of $200.28 per acre (Table 78). This financially optimal rotation would produce an estimated 13.22 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 22.83 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 74). This optimal management regime will generate the maximum SEV of $21.11 (Table 82), with a NPW of $20.49 per acre (Table 78). This financially optimal rotation would produce an estimated 10.46 MBF of sawlogs per acre from the final harvest (Table 86), and sequester 20.08 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 74). This optimal management regime will generate the maximum SEV of -$91.37 (Table 82), with a NPW of -$89.99 per acre (Table 78). This financially optimal rotation would produce an estimated 10.46 MBF of sawlogs per acre from the final harvest (Table 86), and sequester 20.08 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 34 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 45 (Table 74). This optimal management regime will generate the maximum SEV of $5,020.25 (Table 82), with a NPW of $3,408.02 per acre (Table 78). This financially optimal rotation would produce an estimated 24.86 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 30.71 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 35 (Table 74). This optimal management regime will generate the maximum SEV of $1,650.06 (Table 82), with a NPW of $1,365.16 per acre (Table 78). This financially optimal rotation would produce an estimated 18.13 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 25.66 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 34 (Table 74). This optimal management regime will generate the maximum SEV of $673.88 (Table 82), with a NPW of $620.26 per acre (Table 78). This financially optimal rotation would produce an estimated 17.10 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 24.93 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 31 (Table 74). This optimal management regime will generate the maximum SEV of $269.14 (Table 82), with a NPW of $256.39 per acre (Table 78). This financially optimal rotation would

produce an estimated 14.13 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 22.65 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 30 (Table 74). This optimal management regime will generate the maximum SEV of $59.56 (Table 82), with a NPW of $58.02 per acre (Table 78). This financially optimal rotation would produce an estimated 13.01 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 21.94 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 28 (Table 74). This optimal management regime will generate the maximum SEV of -$61.15 (Table 82), with a NPW of -$60.09 per acre (Table 78). This financially optimal rotation would produce an estimated 10.67 MBF of sawlogs per acre from the final harvest (Table 86), and sequester 19.93 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 34 (Table 74). This optimal management regime will generate the maximum SEV of $5,496.94 (Table 82), with a NPW of $3,180.69 per acre (Table 78). This financially optimal rotation would produce an estimated 19.12 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 26.68 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 74). This optimal management regime will generate the maximum SEV of $1,838.63 (Table 82), with a NPW of $1,488.64 per acre (Table 78). This financially optimal rotation would produce an estimated 18.25 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 25.80 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 74). This optimal management regime will generate the maximum SEV of $783.70 (Table 82), with a NPW of $694.19 per acre (Table 78). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 24.72 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 74). This optimal management regime will generate the maximum SEV of $339.61 (Table 82), with a NPW of $320.15 per acre (Table 78). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 24.72 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 74). This optimal management regime will generate the maximum SEV of $105.40 (Table 82), with a NPW of $102.32 per acre (Table 78). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 24.72 net tons of carbon per acre during one rotation (Table 70).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 29 (Table 74). This optimal management regime will generate the maximum SEV of -$31.31 (Table 82), with a NPW of -$30.84 per acre (Table 78). This financially optimal rotation would produce an estimated 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 24.72 net tons of carbon per acre during one rotation (Table 70).

Species Douglas-fir Region Westside Cascades

Site indices 100, 110 and 120 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 29.30, 30.50, and 32.80 from low to high site index. Sawlog volume was measured in Scribner to a 4.5-in. inside bark top diameter for trees with a minimum of 7 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 9-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 15 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.187943262 and 0.709219858, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Grier and Logan (1977) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Y = \exp(-2.656 + 2.530 \ln X)$$

where:

Y = component dry weight (kg)

X = stem diameter at breast height (cm)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.6% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $331/mbf (Scribner) (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices) and pulpwood price was assumed to be $0/cord (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of Douglas-fir plantations in the Westside Cascades.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$80.28	Only once	Year 0	
Seedlings[b] (600 seedlings/ac)	$120	Only Once	Year 0	
Burning[a]	$21.24	Every 5 years	Year 10	Final Harvest
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al (2005).

[b]The seedling cost was estimated based on the seedling prices from Source of Oregon Native Forest Tree Seedlings 2004-2005 by elevation (http://egov.oregon.gov/ODF/PRIVATE_FORESTS/docs/2004Catalog.pdf. February 12, 2006).

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Table 89. Total tons of carbon sequestered per acre for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	29.65	26.02	24.10	22.10	22.10	18.80
110	30.07	28.08	26.10	22.95	21.89	19.81
120	27.95	27.95	27.95	23.95	23.95	23.95

[1]Base age 50.

Table 90. Total tons of carbon sequestered per acre for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	29.65	26.02	24.10	22.10	21.87	18.80
110	30.07	28.08	26.10	22.95	21.89	21.89
120	27.95	27.95	27.95	23.95	23.95	23.95

[1]Base age 50.

Table 91. Total tons of carbon sequestered per acre for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	32.79	26.02	25.24	23.80	21.87	21.87
110	30.07	28.08	26.10	26.10	21.89	21.89
120	31.73	27.95	27.95	23.95	23.95	23.95

[1]Base age 50.

Table 92. Total tons of carbon sequestered per acre for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	32.79	26.02	25.71	23.80	21.87	21.87
110	31.01	28.08	26.10	26.10	21.89	21.89
120	31.73	27.95	27.95	23.95	23.95	23.95

[1]Base age 50.

Table 93. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	24-**32**[2] (20%)[3]	21-**28** (20%)	19-**26** (20%)	17-**24** (20%)	17-**24** (20%)	<15-**21**>[4] (30%)
110	**29**	**27**	**25**	**22**	**21**	<15-**20**> (30%)
120	20-**25** (25%)	20-**25** (25%)	20-**25** (25%)	**21**	**21**	**21**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 94. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	24-**32**[2] (20%)[3]	21-**28** (20%)	19-**26** (20%)	17-**24** (20%)	**23**	<15-**21**>[4] (30%)
110	**29**	**27**	**25**	**22**	**21**	**21**
120	20-**25** (25%)	20-**25** (25%)	20-**25** (25%)	**21**	**21**	**21**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 95. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	**35**	21-**28**[2] (20%)[3]	22-**27** (20%)	**25**	**23**	**23**
110	**29**	**27**	**25**	**25**	**21**	**21**
120	**28**	**25**	20-**25** (25%)	**21**	**21**	**21**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 96. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	**35**	21-**28**[2] (20%)[3]	**27**	**25**	**23**	**23**
110	**30**	**27**	**25**	**25**	**21**	**21**
120	**28**	20-**25** (25%)	20-**25** (25%)	**21**	**21**	**21**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 97. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$4,730.67	$1,952.03	$835.57	$297.03	$18.22	-$129.35
110	$5,654.90	$2,580.35	$1,209.51	$512.02	$174.26	-$24.10
120	$6,464.19	$3,364.86	$1,699.87	$819.12	$371.68	$97.99

[1]Base age 50.

Table 98. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$4,975.07	$2,133.03	$978.93	$412.80	$116.71	-$48.68
110	$5,907.50	$2,778.25	$1,366.78	$636.31	$278.96	$64.56
120	$6,702.20	$3,565.10	$1,868.17	$951.65	$486.15	$197.44

[1]Base age 50.

Table 99. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$5,958.08	$2,621.73	$1,383.12	$732.09	$386.06	$182.35
110	$6,589.54	$3,312.58	$1,791.41	$1,006.81	$561.66	$310.29
120	$7,941.15	$4,105.76	$2,322.58	$1,309.48	$795.22	$465.95

[1]Base age 50.

Table 100. Net present worth of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$6,306.58	$2,857.03	$1,575.85	$889.62	$515.75	$294.33
110	$7,072.63	$3,569.85	$1,995.85	$1,178.97	$697.77	$428.60
120	$8,289.64	$4,366.08	$2,541.37	$1,481.77	$944.03	$595.23

[1]Base age 50.

Table 101. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$8,488.60	$2,578.46	$973.75	$327.23	$19.23	-$135.62
110	$10,807.10	$3,464.00	$1,427.22	$576.39	$188.37	-$25.45
120	$13,644.29	$4,681.49	$2,005.84	$933.84	$401.79	$102.74

[1]Base age 50.

Table 102. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$8,927.15	$2,817.55	$1,140.80	$454.77	$124.06	-$51.04
110	$11,289.86	$3,729.67	$1,612.79	$716.30	$301.56	$67.69
120	$14,146.66	$4,960.08	$2,204.43	$1,084.93	$525.53	$207.00

[1]Base age 50.

Table 103. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$10,117.19	$3,463.08	$1,593.45	$799.14	$410.36	$188.95
110	$12,593.30	$4,446.97	$2,133.85	$1,099.02	$607.15	$325.32
120	$15,530.12	$5,712.29	$2,740.63	$1,492.88	$859.63	$488.52

[1]Base age 50.

Table 104. Soil expectation value of the financially optimal thinning and final harvest schedules for Douglas fir plantations by site index and real alternative rates of return in the westside cascades region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$10,708.96	$3,773.89	$1,815.49	$971.11	$584.21	$304.99
110	$13,222.70	$4,792.34	$2,355.10	$1,286.96	$754.29	$449.36
120	$16,211.64	$6,074.46	$2,998.80	$1,689.29	$1,020.49	$624.06

[1]Base age 50.

Table 105. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in the westside cascades region). (carbon value = $0/ton)

			1st thinning	2nd thinning	Final Harvest	Total Volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
100	2.50%	24-**32**[3] (20%)[4]	0	-	35.99	35.99
	5.00%	21-**28** (20%)	0	-	29.44	29.44
	7.50%	19-**26** (20%)	0	-	25.78	25.78
	10.00%	17-**24** (20%)	0	-	21.53	21.53
	12.50%	17-**24** (20%)	0	-	21.53	21.53
	15.00%	15-**21** (30%)	0	-	14.93	14.93
110	2.50%	**29**	-	-	39.5	39.5
	5.00%	**27**	-	-	35.56	35.56
	7.50%	**25**	-	-	31.31	31.31
	10.00%	**22**	-	-	23.48	23.48
	12.50%	**21**	-	-	21.17	21.17
	15.00%	15-**20** (30%)	0	-	18.57	18.57
120	2.50%	20-**25** (25%)	0	-	40.86	40.86
	5.00%	20-**25** (25%)	0	-	40.86	40.86
	7.50%	20-**25** (25%)	0	-	40.86	40.86
	10.00%	**21**	-	-	28.71	28.71
	12.50%	**21**	-	-	28.71	28.71
	15.00%	**21**	-	-	28.71	28.71

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 106. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in the westside cascades region. (carbon value = $10/ton)

			1st thinning	2nd thinning	Final Harvest	Total Volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
100	2.50%	24-**32**[3] (20%)[4]	0	-	35.99	35.99
	5.00%	21-**28** (20%)	0	-	29.44	29.44
	7.50%	19-**26** (20%)	0	-	25.78	25.78
	10.00%	17-**24** (20%)	0	-	21.53	21.53
	12.50%	**23**	-	-	19.11	19.11
	15.00%	15-**21** (30%)	0	-	14.93	14.93
110	2.50%	**29**	-	-	39.5	39.5
	5.00%	**27**	-	-	35.56	35.56
	7.50%	**25**	-	-	31.31	31.31
	10.00%	**22**	-	-	23.48	23.48
	12.50%	**21**	-	-	21.17	21.17
	15.00%	**21**	-	-	21.17	21.17
120	2.50%	20-**25** (25%)	0	-	40.86	40.86
	5.00%	20-**25** (25%)	0	-	40.86	40.86
	7.50%	20-**25** (25%)	0	-	40.86	40.86
	10.00%	**21**	-	-	28.71	28.71
	12.50%	**21**	-	-	28.71	28.71
	15.00%	**21**	-	-	28.71	28.71

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 107. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in the westside cascades region. (carbon value = $37/ton)

			1st thinning	2nd thinning	Final Harvest	Total Volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
100	2.50%	**35**	-	-	40.35	40.35
	5.00%	21-**28**[4] (20%)[5]	0	-	29.44	29.44
	7.50%	22-**27** (20%)	0	-	27.68	27.68
	10.00%	**25**	-	-	23.25	23.25
	12.50%	**23**	-	-	19.11	19.11
	15.00%	**23**	-	-	19.11	19.11
110	2.50%	**29**	-	-	39.5	39.5
	5.00%	**27**	-	-	35.56	35.56
	7.50%	**25**	-	-	31.31	31.31
	10.00%	**25**	-	-	31.31	31.31
	12.50%	**21**	-	-	21.17	21.17
	15.00%	**21**	-	-	21.17	21.17
120	2.50%	**28**	-	-	46.82	46.82
	5.00%	20-**25** (25%)	0	-	40.86	40.86
	7.50%	20-**25** (25%)	0	-	40.86	40.86
	10.00%	**21**	-	-	28.71	28.71
	12.50%	**21**	-	-	28.71	28.71
	15.00%	**21**	-	-	28.71	28.71

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Indicates no operation conducted.
[4]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[5]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 108. Volume removed from the financially optimal schedules for Douglas fir plantations by soil productivity and real alternative rates of return in the westside cascades region. (carbon value = $50/ton)

			1st thinning	2nd thinning	Final Harvest	Total Volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
100	2.50%	**35**	-	-	40.35	40.35
	5.00%	21-**28**[4] (20%)[5]	0	-	29.44	29.44
	7.50%	**27**	-	-	27.43	27.43
	10.00%	**25**	-	-	23.25	23.25
	12.50%	**23**	-	-	19.11	19.11
	15.00%	**23**	-	-	19.11	19.11
110	2.50%	**30**	-	-	41.32	41.32
	5.00%	**27**	-	-	35.56	35.56
	7.50%	**25**	-	-	31.31	31.31
	10.00%	**25**	-	-	31.31	31.31
	12.50%	**21**	-	-	21.17	21.17
	15.00%	**21**	-	-	21.17	21.17
120	2.50%	**28**	-	-	46.82	46.82
	5.00%	20-**25** (25%)	0	-	40.86	40.86
	7.50%	20-**25** (25%)	0	-	40.86	40.86
	10.00%	**21**	-	-	28.71	28.71
	12.50%	**21**	-	-	28.71	28.71
	15.00%	**21**	-	-	28.71	28.71

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Indicates no operation conducted.
[4]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[5]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 109. Financially optimal thinning and final harvest schedules for Douglas fir plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	100	24-**32**[2] (20%)[3]	24-**32** (20%)	0%	**35**	9%	**35**	9%
	110	**29**	**29**	0%	**29**	0%	**30**	3%
	120	20-**25** (25%)	20-**25** (25%)	0%	**28**	12%	**28**	12%
5.00%	100	21-**28** (20%)	21-**28** (20%)	0%	21-**28** (20%)	0%	21-**28** (20%)	0%
	110	**27**	**27**	0%	**27**	0%	**27**	0%
	120	20-**25** (25%)	20-**25** (25%)	0%	**25**	0%	20-**25** (25%)	0%
7.50%	100	19-**26** (20%)	19-**26** (20%)	0%	22-**27** (20%)	4%	**27**	4%
	110	**25**	**25**	0%	**25**	0%	**25**	0%
	120	20-**25** (25%)	20-**25** (25%)	0%	20-**25** (25%)	0%	20-**25** (25%)	0%
10.00%	100	17-**24** (20%)	17-**24** (20%)	0%	**25**	4%	**25**	4%
	110	**22**	**22**	0%	**25**	14%	**25**	14%
	120	**21**	**21**	0%	**21**	0%	**21**	0%
12.50%	100	17-**24** (20%)	**23**	-4%	**23**	-4%	**23**	-4%
	110	**21**	**21**	0%	**21**	0%	**21**	0%
	120	**21**	**21**	0%	**21**	0%	**21**	0%
15.00%	100	<15-**21**>[4] (30%)	<15-**21**> (30%)	0%	**23**	10%	**23**	10%
	110	<15-**20**> (30%)	**21**	5%	**21**	5%	**21**	5%
	120	**21**	**21**	0%	**21**	0%	**21**	0%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3] Number in parentheses indicates the percentage of basal area removed during thinning

[4] <> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 110. The soil expectation value ($/acre) of the financially optimal rotations for Douglas fir plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	100	8,488.60	8,927.15	5%	10,117.19	19%	10,708.96	26%
	110	10,807.10	11,289.86	4%	12,593.30	17%	13,222.70	22%
	120	13,644.29	14,146.66	4%	15,530.12	14%	16,211.64	19%
5.00%	100	2,578.46	2,817.55	9%	3,463.08	34%	3,773.89	46%
	110	3,464.00	3,729.67	8%	4,446.97	28%	4,792.34	38%
	120	4,681.49	4,960.08	6%	5,712.29	22%	6,074.46	30%
7.50%	100	973.75	1,140.80	17%	1,593.45	64%	1,815.49	86%
	110	1,427.22	1,612.79	13%	2,133.85	50%	2,355.10	65%
	120	2,005.84	2,204.43	10%	2,740.63	37%	2,998.80	50%
10.00%	100	327.23	454.77	39%	799.14	144%	971.11	197%
	110	576.39	716.30	24%	1,099.02	91%	1,286.96	123%
	120	933.84	1,084.93	16%	1,492.88	60%	1,689.29	81%
12.50%	100	19.23	124.06	545%	410.36	2034%	584.21	2938%
	110	188.37	301.56	60%	607.15	222%	754.29	300%
	120	401.79	525.53	31%	859.63	114%	1,020.49	154%
15.00%	100	-135.62	-51.04		188.95		304.99	
	110	-25.45	67.69		325.32		449.36	
	120	102.74	207.00	101%	488.52	375%	624.06	507%

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>Westside Cascades- Douglas-fir - Timber Only Rotations (C = $0/ton)</u>

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 24 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 32 (Table 93). This optimal management regime will generate the maximum SEV of $8,488.60 (Table 101), with a NPW of $4,730.67 per acre (Table 97). This means that $8,488.60 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $4,730.67 per acre for managing one rotation, or $8,488.60 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 35.99 MBF of sawlogs per acre from the thinning and final harvest (Table 105), and sequester 29.65 net tons of carbon per acre during one rotation (Table 89). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 28 (Table 93). This optimal management regime will generate the maximum SEV of $2,578.46 (Table 101), with a NPW of $1,952.03 per acre (Table 97). This financially optimal rotation would

produce an estimated 29.44 MBF of sawlogs per acre from the thinning and final harvest (Table 105), and sequester 26.02 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 19 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 26 (Table 93). This optimal management regime will generate the maximum SEV of $973.75 (Table 101), with a NPW of $835.57 per acre (Table 97). This financially optimal rotation would produce an estimated 25.78 MBF of sawlogs per acre from the thinning and final harvest (Table 105), and sequester 24.10 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 24 (Table 93). This optimal management regime will generate the maximum SEV of $327.23 (Table 101), with a NPW of $297.03 per acre (Table 97). This financially optimal rotation would produce an estimated 21.53 MBF of sawlogs per acre from the thinning and final harvest (Table 105), and sequester 22.10 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 24 (Table 93). This optimal management regime will generate the maximum SEV of $19.23 (Table 101), with a NPW of $18.22 per acre (Table 97). This financially optimal rotation would produce an estimated 21.53 MBF of sawlogs per acre from the thinning and final harvest (Table 105), and sequester 22.10 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 15 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 21 (Table 93). This optimal management regime will generate the maximum SEV of -$135.62 (Table 101), with a NPW of -$129.35 per acre (Table 97). This financially optimal rotation would produce an estimated 14.93 MBF of sawlogs per acre from the thinning and final harvest (Table 105), and sequester 18.80 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 93). This optimal management regime will generate the maximum SEV of $10,807.10 (Table 101), with a NPW of $5,654.90 per acre (Table 97). This financially optimal rotation would

produce an estimated 39.50 MBF of sawlogs per acre from the final harvest (Table 105), and sequester 30.07 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 93). This optimal management regime will generate the maximum SEV of $3,464.00 (Table 101), with a NPW of $2,580.35 per acre (Table 97). This financially optimal rotation would produce an estimated 35.56 MBF of sawlogs per acre from the final harvest (Table 105), and sequester 28.08 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 93). This optimal management regime will generate the maximum SEV of $1,427.22 (Table 101), with a NPW of $1,209.51 per acre (Table 97). This financially optimal rotation would produce an estimated 31.31 MBF of sawlogs per acre from the final harvest (Table 105), and sequester 26.10 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 93). This optimal management regime will generate the maximum SEV of $576.39 (Table 101), with a NPW of $512.02 per acre (Table 97). This financially optimal rotation would produce an estimated 23.48 MBF of sawlogs per acre from the final harvest (Table 105), and sequester 22.95 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 93). This optimal management regime will generate the maximum SEV of $188.37 (Table 101), with a NPW of $174.26 per acre (Table 97). This financially optimal rotation would produce an estimated 21.17 MBF of sawlogs per acre from the final harvest (Table 105), and sequester 21.89 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 15 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 20 (Table 93). This optimal management regime will generate the maximum SEV of -$25.45 (Table 101), with a NPW of -$24.10 per acre (Table 97). This financially optimal rotation would produce an estimated 18.57 MBF of sawlogs per acre from the thinning and final harvest (Table 105), and sequester 13.62 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 25 (Table 93). This optimal management regime will generate the maximum SEV of $13,644.29 (Table 101), with a NPW of $6,464.19 per acre (Table 97). This financially optimal rotation would produce an estimated 40.86 MBF of sawlogs per acre from the thinning and final harvest

(Table 105), and sequester 27.95 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 25 (Table 93). This optimal management regime will generate the maximum SEV of $4,681.49 (Table 101), with a NPW of $3,364.86 per acre (Table 97). This financially optimal rotation would produce an estimated 40.86 MBF of sawlogs per acre from the thinning and final harvest (Table 105), and sequester 27.95 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 25 (Table 93). This optimal management regime will generate the maximum SEV of $2,005.84 (Table 101), with a NPW of $1,699.87 per acre (Table 97). This financially optimal rotation would produce an estimated 40.86 MBF of sawlogs per acre from the thinning and final harvest (Table 105), and sequester 27.95 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 93). This

optimal management regime will generate the maximum SEV of $933.84 (Table 101), with a NPW of $819.12 per acre (Table 97). This financially optimal rotation would produce an estimated 28.71 MBF of sawlogs per acre from the final harvest (Table 105), and sequester 23.95 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 93). This optimal management regime will generate the maximum SEV of $401.79 (Table 101), with a NPW of $371.68 per acre (Table 97). This financially optimal rotation would produce an estimated 28.71 MBF of sawlogs per acre from the final harvest (Table 105), and sequester 23.95 net tons of carbon per acre during one rotation (Table 89).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 93). This optimal management regime will generate the maximum SEV of $102.74 (Table 101), with a NPW of $97.99 per acre (Table 97). This financially optimal rotation would produce an estimated 28.71 MBF of sawlogs per acre from the final harvest (Table 105), and sequester 23.95 net tons of carbon per acre during one rotation (Table 89).

<u>Westside Cascades- Douglas-fir - Timber Only Rotations (C = $10/ton)</u>

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 24 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 32 (Table 94). This optimal management regime will generate the maximum SEV of $8,927.15 (Table 102), with a NPW of $4,975.07 per acre (Table 98). This means that $8,927.15 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $4,975.07 per acre for managing one rotation, or $8,927.15 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 35.99 MBF of sawlogs per acre from the thinning and final harvest (Table 106), and sequester 29.65 net tons of carbon per acre during one rotation (Table 90). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 28 (Table 94). This optimal management regime will generate the maximum SEV of $2,817.55 (Table 102), with a NPW of $2,133.03 per acre (Table 98). This financially optimal rotation would

produce an estimated 29.44 MBF of sawlogs per acre from the thinning and final harvest (Table 106), and sequester 26.02 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 19 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 26 (Table 94). This optimal management regime will generate the maximum SEV of $1,140.80 (Table 102), with a NPW of $978.93 per acre (Table 98). This financially optimal rotation would produce an estimated 25.78 MBF of sawlogs per acre from the thinning and final harvest (Table 106), and sequester 24.10 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 24 (Table 94). This optimal management regime will generate the maximum SEV of $454.77 (Table 102), with a NPW of $412.80 per acre (Table 98). This financially optimal rotation would produce an estimated 21.53 MBF of sawlogs per acre from the thinning and final harvest (Table 106), and sequester 22.10 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 94). This optimal management regime will generate the maximum SEV of $124.06 (Table 102), with a NPW of $116.71 per acre (Table 98). This financially optimal rotation would produce an estimated 19.11 MBF of sawlogs per acre from the final harvest (Table 106), and sequester 21.87 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 15 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 21 (Table 94). This optimal management regime will generate the maximum SEV of -$51.04 (Table 102), with a NPW of -$48.68 per acre (Table 98). This financially optimal rotation would produce an estimated 14.93 MBF of sawlogs per acre from the thinning and final harvest (Table 106), and sequester 18.80 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 94). This optimal management regime will generate the maximum SEV of $11,289.86 (Table 102), with a NPW of $5,907.50 per acre (Table 98). This financially optimal rotation would produce an estimated 39.50 MBF of sawlogs per acre from the final harvest (Table 106), and sequester 30.07 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 94). This optimal management regime will generate the maximum SEV of $3,729.67 (Table 102), with a NPW of $2,778.25 per acre (Table 98). This financially optimal rotation would produce an estimated 35.56 MBF of sawlogs per acre from the final harvest (Table 106), and sequester 28.08 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 94). This optimal management regime will generate the maximum SEV of $1,612.79 (Table 102), with a NPW of $1,366.78 per acre (Table 98). This financially optimal rotation would produce an estimated 31.31 MBF of sawlogs per acre from the final harvest (Table 106), and sequester 26.10 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 94). This optimal management regime will generate the maximum SEV of $716.30 (Table 102), with a NPW of $636.31 per acre (Table 98). This financially optimal rotation would produce an estimated 23.48 MBF of sawlogs per acre from the final harvest (Table 106), and sequester 22.95 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 94). This

optimal management regime will generate the maximum SEV of $301.56 (Table 102), with a NPW of $278.96 per acre (Table 98). This financially optimal rotation would produce an estimated 21.17 MBF of sawlogs per acre from the final harvest (Table 106), and sequester 21.89 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 94). This optimal management regime will generate the maximum SEV of $67.69 (Table 102), with a NPW of $64.56 per acre (Table 98). This financially optimal rotation would produce an estimated 21.17 MBF of sawlogs per acre from the final harvest (Table 106), and sequester 21.89 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 25 (Table 94). This optimal management regime will generate the maximum SEV of $14,146.66 (Table 102), with a NPW of $6,702.20 per acre (Table 98). This financially optimal rotation would produce an estimated 40.86 MBF of sawlogs per acre from the thinning and final harvest (Table 106), and sequester 27.95 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 25 percent of

basal area removed) and a final harvest is conducted at stand age 25 (Table 94). This optimal management regime will generate the maximum SEV of $4,960.08 (Table 102), with a NPW of $3,565.10 per acre (Table 98). This financially optimal rotation would produce an estimated 40.86 MBF of sawlogs per acre from the thinning and final harvest (Table 106), and sequester 27.95 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 25 (Table 94). This optimal management regime will generate the maximum SEV of $2,204.43 (Table 102), with a NPW of $1,868.17 per acre (Table 98). This financially optimal rotation would produce an estimated 40.86 MBF of sawlogs per acre from the thinning and final harvest (Table 106), and sequester 27.95 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 94). This optimal management regime will generate the maximum SEV of $1,084.93 (Table 102), with a NPW of $951.65 per acre (Table 98). This financially optimal rotation would produce an estimated 28.71 MBF of sawlogs per acre from the final harvest (Table 106), and sequester 23.95 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 94). This optimal management regime will generate the maximum SEV of $525.53 (Table 102), with a NPW of $486.15 per acre (Table 98). This financially optimal rotation would produce an estimated 28.71 MBF of sawlogs per acre from the final harvest (Table 106), and sequester 23.95 net tons of carbon per acre during one rotation (Table 90).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 94). This optimal management regime will generate the maximum SEV of $207.00 (Table 102), with a NPW of $197.44 per acre (Table 98). This financially optimal rotation would produce an estimated 28.71 MBF of sawlogs per acre from the final harvest (Table 106), and sequester 23.95 net tons of carbon per acre during one rotation (Table 90).

Westside Cascades-Douglas-fir - Timber Only Rotations (C = $37/ton)

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 35 (Table 95). This optimal management regime will generate the maximum SEV of $10,117.19 (Table 103), with a NPW of $5,958.08 per acre (Table 99). This means that $10,117.19 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $5,958.08 per acre for managing one rotation, or $10,117.19 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 40.35 MBF of sawlogs per acre from the final harvest (Table 107), and sequester 32.79 net tons of carbon per acre during one rotation (Table 91). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 28 (Table 95). This optimal management regime will generate the maximum SEV of $3,463.08 (Table 103), with a NPW of $2,621.73 per acre (Table 99). This financially optimal rotation would produce an estimated 29.44 MBF of sawlogs per acre from the thinning and final harvest (Table 107), and sequester 26.02 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 22 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 95). This optimal management regime will generate the maximum SEV of $1,593.45 (Table 103), with a NPW of $1,383.12 per acre (Table 99). This financially optimal rotation would produce an estimated 27.68 MBF of sawlogs per acre from the thinning and final harvest

(Table 107), and sequester 25.24 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 95). This optimal management regime will generate the maximum SEV of $799.14 (Table 103), with a NPW of $732.09 per acre (Table 99). This financially optimal rotation would produce an estimated 23.25 MBF of sawlogs per acre from the final harvest (Table 107), and sequester 23.80 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 95). This optimal management regime will generate the maximum SEV of $410.36 (Table 103), with a NPW of $386.06 per acre (Table 99). This financially optimal rotation would produce an estimated 19.11 MBF of sawlogs per acre from the final harvest (Table 107), and sequester 21.87 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 95). This optimal management regime will generate the maximum SEV of $188.95 (Table 103), with a NPW of $182.35 per acre (Table 99). This financially optimal rotation would produce an estimated 19.11 MBF of sawlogs per acre from the final harvest (Table 107), and sequester 21.87 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 29 (Table 95). This optimal management regime will generate the maximum SEV of $12,593.30 (Table 103), with a NPW of $6,589.54 per acre (Table 99). This financially optimal rotation would produce an estimated 39.50 MBF of sawlogs per acre from the final harvest (Table 107), and sequester 30.07 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 95). This optimal management regime will generate the maximum SEV of $4,446.97 (Table 103), with a NPW of $3,312.58 per acre (Table 99). This financially optimal rotation would produce an estimated 35.56 MBF of sawlogs per acre from the final harvest (Table 107), and sequester 28.08 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 95). This optimal management regime will generate the maximum SEV of $2,133.85 (Table 103), with a NPW of $1,791.41 per acre (Table 99). This financially optimal rotation would produce an estimated 31.31 MBF of sawlogs per acre from the final harvest (Table 107), and sequester 26.10 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 95). This optimal management regime will generate the maximum SEV of $1,099.02 (Table 103), with a NPW of $1,006.81 per acre (Table 99). This financially optimal rotation would produce an estimated 31.31 MBF of sawlogs per acre from the final harvest (Table 107), and sequester 26.10 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 95). This optimal management regime will generate the maximum SEV of $607.15 (Table 103), with a NPW of $561.66 per acre (Table 99). This financially optimal rotation would produce an estimated 21.17 MBF of sawlogs per acre from the final harvest (Table 107), and sequester 21.89 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 95). This optimal management regime will generate the maximum SEV of $325.32 (Table 103), with a NPW of $310.29 per acre (Table 99). This financially optimal rotation would produce an estimated 21.17 MBF of sawlogs per acre from the final harvest (Table 107), and sequester 21.89 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 28 (Table 95). This

optimal management regime will generate the maximum SEV of $15,530.12 (Table 103), with a NPW of $7,941.15 per acre (Table 99). This financially optimal rotation would produce an estimated 46.82 MBF of sawlogs per acre from the final harvest (Table 107), and sequester 31.73 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 25 (Table 95). This optimal management regime will generate the maximum SEV of $5,712.29 (Table 103), with a NPW of $4,105.76 per acre (Table 99). This financially optimal rotation would produce an estimated 40.86 MBF of sawlogs per acre from the thinning and final harvest (Table 107), and sequester 27.95 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 25 (Table 95). This optimal management regime will generate the maximum SEV of $2,740.63 (Table 103), with a NPW of $2,322.58 per acre (Table 99). This financially optimal rotation would produce an estimated 40.86 MBF of sawlogs per acre from the thinning and final harvest (Table 107), and sequester 27.95 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 95). This optimal management regime will generate the maximum SEV of $1,492.88 (Table 103), with a NPW of $1,309.48 per acre (Table 99). This financially optimal rotation would produce an estimated 28.71 MBF of sawlogs per acre from the final harvest (Table 107), and sequester 23.95 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 95). This optimal management regime will generate the maximum SEV of $859.63 (Table 103), with a NPW of $795.22 per acre (Table 99). This financially optimal rotation would produce an estimated 28.71 MBF of sawlogs per acre from the final harvest (Table 107), and sequester 23.95 net tons of carbon per acre during one rotation (Table 91).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 95). This optimal management regime will generate the maximum SEV of $488.52 (Table 103), with a NPW of $465.95 per acre (Table 99). This financially optimal rotation would produce an estimated 28.71 MBF of sawlogs per acre from the final harvest (Table 107), and sequester 23.95 net tons of carbon per acre during one rotation (Table 91).

Westside Cascades- Douglas-fir - Timber Only Rotations (C = $50/ton)

Douglas-fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 35 (Table 96). This optimal management regime will generate the maximum SEV of $10,708.96 (Table 104), with a NPW of $6,306.58 per acre (Table 100). This means that $10,708.96 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $6,306.58 per acre for managing one rotation, or $10,708.96 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 40.35 MBF of sawlogs per acre from the final harvest (Table 108), and sequester 32.79 net tons of carbon per acre during one rotation (Table 92). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Douglas-fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 21 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 28 (Table 96). This optimal management regime will generate the maximum SEV of $3,773.89 (Table 104), with a NPW of $2,857.03 per acre (Table 100). This financially optimal rotation would produce an estimated 29.44 MBF of sawlogs per acre from the thinning and final harvest

(Table 108), and sequester 26.02 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 96). This optimal management regime will generate the maximum SEV of $1,815.49 (Table 104), with a NPW of $1,575.85 per acre (Table 100). This financially optimal rotation would produce an estimated 27.43 MBF of sawlogs per acre from the final harvest (Table 108), and sequester 25.71 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 96). This optimal management regime will generate the maximum SEV of $971.11 (Table 104), with a NPW of $889.62 per acre (Table 100). This financially optimal rotation would produce an estimated 23.25 MBF of sawlogs per acre from the final harvest (Table 108), and sequester 23.80 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 96). This optimal management regime will generate the maximum SEV of $584.21 (Table 104), with a NPW of $515.75 per acre (Table 100). This financially optimal rotation would produce an estimated 19.11 MBF of sawlogs per acre from the final harvest (Table 108), and sequester 21.87 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 96). This optimal management regime will generate the maximum SEV of $304.99 (Table 104), with a NPW of $294.33 per acre (Table 100). This financially optimal rotation would produce an estimated 19.11 MBF of sawlogs per acre from the final harvest (Table 108), and sequester 21.87 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 30 (Table 96). This optimal management regime will generate the maximum SEV of $13,222.70 (Table 104), with a NPW of $7,072.63 per acre (Table 100). This financially optimal rotation would produce an estimated 41.32 MBF of sawlogs per acre from the final harvest (Table 108), and sequester 31.01 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 96). This optimal management regime will generate the maximum SEV of $4,792.34 (Table 104), with a NPW of $3,569.85 per acre (Table 100). This financially optimal rotation would produce an estimated 35.56 MBF of sawlogs per acre from the final harvest (Table 108), and sequester 28.08 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 96). This optimal management regime will generate the maximum SEV of $2,355.10 (Table 104), with a NPW of $1,995.85 per acre (Table 100). This financially optimal rotation would produce an estimated 31.31 MBF of sawlogs per acre from the final harvest (Table 108), and sequester 26.10 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 96). This optimal management regime will generate the maximum SEV of $1,286.96 (Table 104), with a NPW of $1,178.97 per acre (Table 100). This financially optimal rotation would produce an estimated 31.31 MBF of sawlogs per acre from the final harvest (Table 108), and sequester 26.10 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 96). This optimal management regime will generate the maximum SEV of $754.29 (Table 104), with a NPW of $697.77 per acre (Table 100). This financially optimal rotation would produce an estimated 21.17 MBF of sawlogs per acre from the final harvest (Table 108), and sequester 21.89 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 96). This

optimal management regime will generate the maximum SEV of $449.36 (Table 104), with a NPW of $428.60 per acre (Table 100). This financially optimal rotation would produce an estimated 21.17 MBF of sawlogs per acre from the final harvest (Table 108), and sequester 21.89 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 28 (Table 96). This optimal management regime will generate the maximum SEV of $16,211.64 (Table 104), with a NPW of $8,289.64 per acre (Table 100). This financially optimal rotation would produce an estimated 46.82 MBF of sawlogs per acre from the final harvest (Table 108), and sequester 31.73 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 25 (Table 96). This optimal management regime will generate the maximum SEV of $6,074.46 (Table 104), with a NPW of $4,366.08 per acre (Table 100). This financially optimal rotation would produce an estimated 40.86 MBF of sawlogs per acre from the thinning and final harvest (Table 108), and sequester 27.95 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 25 percent of

basal area removed) and a final harvest is conducted at stand age 25 (Table 96). This optimal management regime will generate the maximum SEV of $2,998.80 (Table 104), with a NPW of $2,541.37 per acre (Table 100). This financially optimal rotation would produce an estimated 40.86 MBF of sawlogs per acre from the thinning and final harvest (Table 108), and sequester 27.95 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 96). This optimal management regime will generate the maximum SEV of $1,689.29 (Table 104), with a NPW of $1,481.77 per acre (Table 100). This financially optimal rotation would produce an estimated 28.71 MBF of sawlogs per acre from the thinning and final harvest (Table 108), and sequester 23.95 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 96). This optimal management regime will generate the maximum SEV of $1,020.49 (Table 104), with a NPW of $944.03 per acre (Table 100). This financially optimal rotation would produce an estimated 28.71 MBF of sawlogs per acre from the thinning and final harvest (Table 108), and sequester 23.95 net tons of carbon per acre during one rotation (Table 92).

Douglas-fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 96). This optimal management regime will generate the maximum SEV of $624.06 (Table 104), with a NPW of $595.23 per acre (Table 100). This financially optimal rotation would produce an estimated 28.71 MBF of sawlogs per acre from the thinning and final harvest (Table 108), and sequester 23.95 net tons of carbon per acre during one rotation (Table 92).

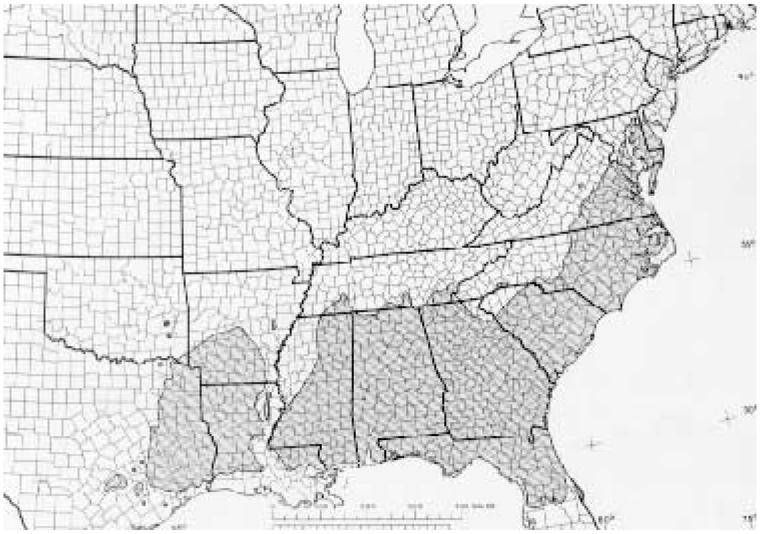
Loblolly Pine (*Pinus taeda*)

Biological Information

Loblolly pine, also referred to as Arkansas pine, North Carolina pine, and oldfield pine, is the most important commercial tree species in the southern United States. Loblolly pine is dominant on about 11.7 million ha (29 million acres) and makes up over one-half of the standing pine volume. The characteristics of loblolly pine include being medium-lived and intolerant to moderately tolerant, having rapid juvenile growth and responding well to silvicultural treatments. Loblolly pine can be managed as either even-aged or uneven-aged natural stands, and can be regenerated artificially and managed in plantations (Burns and Honkala 1990).

Native Range

The native range of loblolly pine extends through 14 States from southern New Jersey south to central Florida and west to eastern Texas. Loblolly pine, an adaptable species, has been successfully planted along the periphery of its natural range and has been introduced to other continents with varying degrees of success (Burns and Honkala 1990).



The native range of loblolly pine.

Growth and Yield

Compared to most hardwood competitors, loblolly pine stands have better growth and its growth doubles or triples the production of common associates on many sites. Mean annual cubic volume growth of loblolly pine generally culminates at about age 40 on average sites (i.e. site index 90) with approximately 8.0 m^3/ha (115 ft^3/acre); however, as a result of larger sawtimber merchantability limits, mean annual board-foot growth culminates at about age 50 at a rate of 9.5 m^3/ha (680 fbm/acre). On better sites, mean annual increment culminates earlier than on poorer ones. Average total solid-wood yields of unthinned loblolly pine planted at 1,730 seedlings per hectare (700/acre) on non-old-field sites at various locations within its range were predicted to increase from approximately 155 m^3/ha (2,200 ft^3/acre) at age 15 to 300 m^3/ha (4,200 ft^3/acre) at age 30 with an estimated mean annual increment of 10 m^3/ha (145 ft^3/acre) (Burns and Honkala 1990).

Growth of loblolly pine may be affected adversely by drought, excess moisture (flooding), and nutrient deficiencies. Drainage (including bedding) and fertilization have been shown to increase dominant height and basal-area growth, resulting in dramatic increases in volume growth. Therefore, sites of cutover lands are usually prepared, and fertilized, if necessary, to correct nutrient deficiencies. Treatments may be applied to control competition, and to supply nutrients at optimum levels to establish vigorous, uniform stands at spacings that will fully utilize site potentials (Burns and Honkala 1990).

Yields of planted loblolly pine vary with plantation age, site quality, number of trees planted, and interactions of these variables. Yields generally increase with increasing age, site quality and higher planting density (closer spacing). On some sites, moderately wide spacing of 8 by 8 ft or 10 by 10 ft has shown to perform best. Initial spacing can be closer on better sites due to their ability of carrying more stocking than poor sites. Closer spacing tends to produce higher total cubic volumes at younger ages than does wider spacing but average tree sizes are smaller on closer spacings. Wider spacing (lower density) would be favorable if sawtimber is a primary management objective. Thinning seldom increases cubic volume yield of loblolly pine but light thinnings salvage suppressed and moribund trees and increase net yields by as much as 20 percent in 50 years. Thinnings increase diameter growth of residual trees, allow the growth to be put on the better trees in the stand and provide intermediate returns on investment (Burns and Honkala 1990).

Loblolly pine expresses dominance at an early age, and the most vigorous individuals that are best adapted to the microsite environment become dominants as the stand ages. Differences in growth rate of individual loblolly pines are evident at early ages in sapling stands when competition between trees begins. The growth differentiation process begins at earlier ages on better sites or at higher levels of stocking, and begins later on poor sites or at low levels of stocking. This differentiation in height growth process, a critical factor in the occupation of available space, separates trees into crown classes. Faster growing trees develop larger live-crown ratios than do slower growing trees. Diameter growth of individual trees generally increases as crown surface area and crown ratio increase. When trees have at least a 40 percent live-crown ratio, optimal diameter growth occurs (Burns and Honkala 1990).

Special Uses

Natural stands and intensively managed plantations of loblolly pine provide habitat for a variety of game and nongame wildlife species. The primary game species that inhabit pine and pine-hardwood forests include white-tailed deer, gray and fox squirrel, bobwhite quail, wild turkey, mourning doves and rabbits. Some of these species utilize the habitat through all stages of stand development; however, others only utilize the forests for a short time during a particular stage of development. For example, a loblolly pine plantation can provide forage for deer only from the time of planting to crown closure occurring in 8 to 10 years if no management practices are modified. Bobwhite quail use the plantation until there is a decline in favored food species. Deer and quail usually move to mature pine or pine-hardwood forests or to other newly established plantations as the habitat deteriorates. Wild turkeys inhabit upland pine and pine-hardwood forests and are attracted to large tracts of mature timber with frequent openings and prescribed burnings. Management modifications include practicing wider planting spacing and early and frequent thinnings to delay crown closure, and conducting periodic prescribed bums to stimulate wildlife food production. Pine lands are the chief habitat for birds such as the pine warbler, brown-headed nuthatch and Bachman's warbler. Large loblolly pine trees are favorite roosting places for many birds and provide an important nesting site for ospreys and the bald eagle. Old-growth stands are very important to the existence of the red-cockaded woodpecker (Burns and Honkala 1990).

In urban forestry, loblolly pines often are used as shade trees and wind and noise barriers. With rapid growth and site occupancy and good litter production, loblolly pine provides the services of soil stabilization and control of areas subject to severe surface erosion and gullying. Additionally, using biomass obtained from precommercial thinnings and logging residue in loblolly pine stands as energy sources is predicted to increase and may become a reality (Burns and Honkala 1990).

Economic Background

Klemperer and Arthaud (1987) examined economics of high and low thinning in loblolly pine. FORTE, a dynamic programming model, was applied to select economically optimal thinning regimes which maximized net present value for low and high thinnings using cost and revenue assumptions typical for Virginia. Results indicate that as site quality increased, optimal rotations decreased and the advantage of low thinning over high thinning increased. Low thinning was still optimal when interest rate was increased to 8%.

Conger and Corty (1986) evaluated economic returns associated with loblolly pine production under various management alternatives in north central Louisiana.

Results indicate that using a 12% interest rate, investing in loblolly pine production on site indices 70, 80, 85 and 90 land was profitable for all thinning and rotation options analyzed in the study. However, net present worth varied greatly between alternative harvesting regimes, methods of regeneration, types of sites regenerated and site indices of land.

Dubois et al. (2001) used thirty-six years of historical growth and yield data from a site preparation study to evaluate historic and projected economic returns to loblolly pine plantation management. This study examined five site preparation treatments to control hardwood competition, and they were a check, girdling without herbicide, stem injection with herbicide, axe frilling with herbicide, and scarification with a bulldozer. Results show that pine plantations established using either the injection, axe frill or bulldoze site preparation treatments with rotation ages of 34 or 36 years had the highest land expectation values.

Borders and Bailey (2001) investigated cultural treatments conducted on six loblolly pine research sites in Georgia and attempted to explain why pines native to the southeastern United States exhibit radically greater growth rates when planted in other parts of the world. Cultural treatments in the Georgia study include complete control of vegetation other than the planted pines with multiple applications of herbicide, annual fertilization, the combination of complete vegetation control and annual fertilization, and an intensive mechanical site preparation treatment. Complete vegetation control resulted in higher yield production at ages 10 to 12 years than the intensive mechanical treatment at all locations, and higher yield production than the annual fertilization treatment at four of six locations. Borders and Bailey (2001) concluded that current growth rates of loblolly pine plantations in the southeastern United States is below their potentials, and intensive plantation management of loblolly pine can be economically justified with the achievement of mean annual increment of 3 or more cords per acre.

Fusifrom rust is a widespread and damaging disease of loblolly pine and slash pine. Cubbage et al. (2000) compared the cost of fusiform rust research to the simulated benefits of rust resistant seedlings in plantations that have been or are projected to be established Southwide between 1970 and 2020. Results showed that using a 4% real discount rate, compounded fusifrom rust research costs of $49 millions in 1992 will return discounted benefit to plantation owners of between $108 and $999 million in 1992. The most probable targeting of rust resistant seedlings would provide estimated discount benefits of fusiform rust protection of about $200 to $300 million in 1992 or annual discounted benefits of $40 to $60 million generating benefit-cost ratios of about 4:1 to 6:1 for fusiform rust research.

Yin (1997) introduced the modified Faustmann-Samuelson-Smith (FSS) model, an alternative to the traditional Faustmann formulation to evaluate forest investment. Results indicate that unlike the Faustmann formulation, a net present value model working at the stand level, the modified FSS model can explicitly reveal the cost structure and capture simultaneous changes in inputs and output uses in timber production. The opportunity cost of capital in the form of stocking volume is the predominant component of total costs in timber production; however, land rental cost and operating cost account for a small percentage of the total cost.

Shiver (1994) evaluated the response of planted slash and loblolly pines to mid-rotation competition control. Total control of competing vegetation resulted in annual gains of 0.25 and 0.35 cords per acre after 14 years and 8 years for slash pine and loblolly pine, respectively. The average gains over all locations indicate that mid-rotation control is economical at some stumpage prices and discount rates. For loblolly pine, top slope positions did not respond as well as mid-slope or bottom slope positions. Shiver (1994) concluded that mid-rotation release deserves consideration with other silvicultural treatments even when a pine stand is already well established.

Clason (1993) evaluated effects of various vegetation management regimes on economic potential of a 35-year-old loblolly pine plantation. Sixteen management regimes were developed based on various silvicultural practices. Silvicultural practices include: two planting densities (680 and 450 TPA), site preparation withy and without herbaceous weed control, age 7 hardwood suppression treatment and two stocking control treatments (unthinned and thinned). Cost effectiveness of the 16 regimes was compared using present net value from historic costs and revenues between 1955 and 1990 computed at an 8% discount rate. The highest net value was produced by a 35-year multiproduct rotation planted at 450 TPA and using the most intensive competition management regime.

Baldwin and Busby (1993) compared predicted mensurational and economic performance of thinned Louisiana loblolly and slash pine plantations. Using the COMPUTE series growth and yield models, stand and stock tables for similar plantations of loblolly and slash pine managed under several alternative thinning schemes were predicted. Land expectation values were calculated using the predictions of sawtimber and pulpwood revenue derived from intermediate and final harvests and reasonable costs of seedlings, planting and stand management for three discount rates (3, 5 and 7%).

Mensurationally and economically loblolly pine outperformed slash pine on better sites; however, slash pine overall performed better on average and poor sites.

Haight (1993) used the North Carolina State University Plantation Management Simulator, a widely used model in the southeastern United States, to conduct an economic analysis of loblolly pine plantation management options with stochastic sawtimber and pulpwood stumpage price trends. Results indicate that, given a range of site indices, regimes with high planting densities combined with commercial thinning options have higher expected present values than do regimes without thinning options, especially in plantations with hardwood competition. High planting densities increase the returns from pulpwood thinnings without compromising sawtimber volume at rotation age, and remain the option to produce either sawtimber or pulpwood depending on the stumpage prices at mid-rotation. Depending on the sawtimber and pulpwood prices at the time of planting, optimal regimes varies. When the hardwood stumpage price is likely to increase over time, removing hardwoods with commercial thinning is superior to removing hardwoods immediately after planting. For deterministic price trends, optimal planting and thinning regimes provide near-optimal expected returns when employed in an environment where price trends are stochastic.

Stearns-Smith et al. (1992) examined the biological and economic effects of thinning and fertilizing southern pine stands in the lower Costal Plain of the southeastern United States. Results indicate that the treatment combination that maximized stand volume production did not always generate the maximum soil expectation value. The increased growth rates resulted from thinning, fertilization, or both tend to extend the optimal rotation. Fertilization is economically superior to other treatments at a 4% real cost of capital with harvest merchandizing of pulpwood and chip-n-saw product classes. Yet, fertilization is discouraged if the cost of capital is increased to 6% or merchandizing solely for pulpwood.

Watson et al. (1992) addressed opportunities for reducing stand reestablishment costs by intensive utilization during harvesting and evaluated the economic impact of these strategies on subsequent stands. Savings on site preparation range from $25/ac to $100/ac for the stands where intensive utilization of the aboveground biomass was implemented. Significant differences in growth or survival were uncommon on re-established stands which received a mechanical site preparation treatment following harvesting to either conventional or intensive utilization standards.

Haight and Smith (1991) examined the effects of stochastic stumpage prices on economic optimal thinning and rotation ages for loblolly pine plantations in the Piedmont region of North Carolina where a price premium for sawtimber is realized. They concluded that a dynamic programming model with a backward recurrence relation is an efficient method for computing thinning intensities and clearcut ages with stochastic stumpage prices. Optimal full-rotation management strategies for both pure and mixed-species plantations derived from the given assumptions illustrate that sawtimber and pulpwood price variation do not affect the timing and intensity of early commercial thinning but stumpage price variation does affect the timing of clearcutting.

Taylor and Fortson (1991) developed a stochastic simulations model to estimate the impacts of site index, planting density and rotation age on the return and risk of unthinned loblolly pine plantations. Return was estimated at the average present value of an infinite series of rotation for each site, density and age combination. Risk (i.e.

stumpage rate, survival, yield) was approximated as the standard deviation of the present value for each combination. Results indicate that variability in yield estimates was the major source of financial risk, and volatility in stumpage rates had the least impact on the risk of the investment. For average sites (site index 60 base age 25 years), short rotations are less risky but have lower returns than longer rotations. For sites with site index 50 base age 25, low planting densities (less than 600 stems/ac) are not efficient. High planting densities and short rotations should be preferred by risk adverse investors. High planting densities and longer rotations should be practiced by investors who wish to maximize return.

Dangerfield and Edwards (1991) compared the profitability of natural and planted regeneration of loblolly pine. This study examined seed tree and shelterwood methods of loblolly pine regeneration and performed profitability analysis. Natural loblolly regeneration appears to be financially competitive with clearcut and plant silviculture. Natural regeneration generated an internal rate of return (IRR) of 10.8%; site preparation and planting generated an IRR of 10.1%, after taxes and adjustment for inflation.

Break-even yield analysis, appropriate for analyzing regeneration activities and intermediate stand treatments, allows a decision-maker to view the results of a financial analysis in terms of the minimum physical volume yield required to earn a specific rate if return on investment capital. Using loblolly pine regeneration and precommercial thinning as examples, Fox (1988) used break-even yield analysis to estimate returns on forest investments.

Resigned (1985) linked four simulation programs (PTAEDAR, PTAEDA, GENMAC and HSS) to predict tree growth/stand development and to model mechanized thinning and final harvest. Simulation results were then combined with an investment analysis program to calculate the net present value of each scenario. Results indicate that long-term economic advantages slightly favor the thinning regimes; the after-tax net present value for the single thin regime was 23%, 22% and 13% higher than those for the no-thin regime at 25-, 30- and 35-year rotations, respectively.

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Species Loblolly pine Region South

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 7-in. inside bark top diameter for trees with a minimum of 10 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 9-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 15 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a “thinning and final harvest” regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 25, 30 and 35% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.194648829 and 0.668896321, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Baldwin (1987) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Ln(BDWob) = 3.31353+1.91029Ln(D)+1.19118Ln(H)+0.000076A^2$$

$$Ln(CDWW) = 0.379049+3.454388Ln(D)+-1.088445Ln(H)$$

$$Ln(CDWB) = 0.264828+3.033934Ln(D)+-1.109824Ln(H)$$

$$Ln(CDWF) = 2.796233+2.912819Ln(D)+-1.474651Ln(H)$$

where:

BDWob = predicted bole weight (lb.) from a 6-in.stump

CDWW = dry-weight (lb.) of crown wood

CDWB = dry-weight (lb.) of crown bark

CDWF = dry-weight (lb.) of crown foliage

D = diameter at breast height (in.)

H = total tree height (ft.)

A = age from planting

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.6% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $296/mbf (Scribner) (Timber Mart South, Inc. 2000-2005) and pulpwood price was assumed to be $18.43/cord (Timber Mart South, Inc. 2000-2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of loblolly pine plantations in the South.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$80.28	Only once	Year 0	
Seedlings[a] (600 seedlings/ac)	$25.81	Only Once	Year 0	
Burning[a]	$21.24	Every 5 years	Year 10	Final Harvest
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al (2005).

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Table 1. Total tons of carbon sequestered per acre for loblolly pine plantations in the southern United States by site index and real alternative rates of return. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	51.03	40.28	35.16	33.92	33.92	32.15
80	58.10	43.82	38.75	36.72	34.94	34.94
90	66.98	47.11	45.79	38.96	38.96	38.96

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for loblolly pine plantations in the southern United States by site index and real alternative rates of return. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	51.03	40.28	40.28	35.16	33.92	32.15
80	59.18	43.82	41.50	36.76	34.94	34.94
90	66.98	50.04	45.79	38.96	38.96	38.96

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for loblolly pine plantations in the southern United States by site index and real alternative rates of return. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	51.03	41.35	40.97	38.92	38.65	38.65
80	59.18	48.13	43.36	41.76	40.87	38.25
90	69.55	47.11	47.11	46.42	44.08	44.08

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for loblolly pine plantations in the southern United States by site index and real alternative rates of return. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	51.03	44.98	42.15	40.57	39.95	41.62
80	60.23	48.13	47.04	44.92	44.62	44.57
90	69.55	49.35	50.44	49.34	46.37	50.07

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for loblolly pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	22-**60**[2] (35%)[3]	23-29-**48** (30%)	<23-30-**44**>[4] (35%)	<23-28-**43**> (35%)	<23-28-**43**> (35%)	<23-28-**41**> (35%)
80	21-53-**59** (35%)	21-27-**45** (30%)	<21-26-**42**> (35%)	<21-26-**40**> (35%)	<21-27-**38**> (35%)	<21-27-**38**> **(35%)**
90	19-51-**59** (35%)	19-24-**42** (30%)	19-24-**41** (30%)	<19-24-**37**> (35%)	<19-24-**37**> (35%)	<19-24-**37**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for loblolly pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	22-**60**[2] (35%)[3]	23-29-**48** (30%)	23-29-**48** (30%)	<23-30-**44**>[4] (35%)	<23-28-**43**> (35%)	<23-28-**41**> (35%)
80	21-55-**60** (35%)	21-27-**45** (30%)	22-27-**43** (30%)	<22-27-**40**> (35%)	<21-27-**38**> (35%)	<21-27-**38**> (35%)
90	19-51-**59** (35%)	22-28-**44** (25%)	19-24-**41** (30%)	19-24-**37** (35%)	<19-24-**37**> (35%)	<19-24-**37**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for loblolly pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	22-**60**[2] (35%)[3]	23-29-**49** (30%)	23-33-**48** (30%)	25-35-**46** (30%)	25-32-**45** (25%)	<25-32-**45**>[4] (25%)
80	21-55-**60** (35%)	22-28-**49** (25%)	21-30-**44** (30%)	23-30-**43** (30%)	24-31-**42** (30%)	25-34-**40** (35%)
90	19-53-**60** (30%)	19-24-**42** (30%)	19-24-**42** (30%)	21-30-**41** (30%)	22-30-**39** (30%)	22-30-**39** (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for loblolly pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	22-**60**[2] (35%)[3]	24-30-**53** (25%)	28-36-**49** (25%)	29-34-**47** (25%)	32-38-**47** (30%)	40-**48** (35%)
80	21-54-**60** (30%)	22-28-**49** (25%)	28-33-**47** (25%)	26-31-**45** (25%)	38-**44** (35%)	39-**44** (35%)
90	19-53-**60** (30%)	19-28-**43** (30%)	25-30-**44** (25%)	25-31-**43** (25%)	26-31-**41** (30%)	36-**43** (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for loblolly pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$2,055.21	$336.79	-$91.40	-$223.20	-$269.73	-$285.62
80	$2,524.77	$492.30	-$17.02	-$186.11	-$250.10	-$275.67
90	$3,003.81	$675.46	$69.92	-$141.12	-$226.85	-$263.69

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for loblolly pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$2,390.67	$529.66	$42.13	-$122.54	-$189.68	-$220.39
80	$2,932.70	$715.87	$141.17	-$64.34	-$152.07	-$194.21
90	$3,451.39	$899.15	$259.54	$1.21	-$110.03	-$165.58

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for loblolly pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$3,296.39	$1,058.00	$418.14	$155.62	$29.53	-$42.20
80	$3,989.00	$1,350.72	$588.66	$273.35	$117.16	$27.84
90	$4,711.47	$1,611.65	$774.95	$400.44	$211.86	$103.65

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for loblolly pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$3,732.48	$1,337.65	$602.82	$295.41	$138.54	$46.05
80	$4,501.76	$1,661.16	$812.33	$441.91	$251.50	$139.01
90	$5,313.60	$1,960.64	$1,036.17	$601.93	$372.32	$237.67

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for loblolly pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$2,640.78	$370.74	-$95.13	-$226.62	-$271.25	-$286.43
80	$3,267.39	$550.67	-$17.81	-$189.93	-$252.65	-$276.86
90	$3,887.34	$769.93	$73.44	-$145.00	-$229.46	-$265.00

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for loblolly pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$3,071.81	$583.05	$43.38	-$124.24	-$190.75	-$221.02
80	$3,768.27	$800.75	$147.28	-$65.66	-$153.62	-$195.05
90	$4,466.57	$1,011.75	$272.61	$1.24	-$111.30	-$166.40

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for loblolly pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$4,235.59	$1,159.07	$430.59	$157.41	$29.66	-$42.27
80	$5,125.54	$1,479.76	$612.30	$277.53	$117.90	$27.93
90	$6,053.86	$1,837.07	$811.14	$407.89	$213.78	$104.03

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for loblolly pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$4,795.93	$1,441.04	$619.48	$298.49	$139.02	$46.10
80	$5,784.39	$1,819.86	$838.38	$447.49	$252.77	$139.26
90	$6,827.54	$2,220.08	$1,077.78	$611.15	$374.99	$238.18

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for loblolly pine plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	22-**60**[3] (35%)[4]	569.77	0	-[5]	-	544.51	28.13	1,114.28	28.13
	5.00%	23-29-**48** (30%)	624.69	0	750.70	0	500.76	18.80	1,876.15	18.80
	7.50%	23-30-**44** (35%)	745.28	0	875.28	0	433.68	14.44	2,054.24	14.44
	10.00%	23-28-**43** (35%)	745.28	0	780.81	0	588.09	13.27	1,333.37	13.27
	12.50%	23-28-**43** (35%)	745.28	0	780.81	0	588.09	13.27	1,333.37	13.27
	15.00%	23-28-**41** (35%)	745.28	0	780.81	0	870.08	10.56	1,615.36	10.56
80	2.50%	21-53-**59** (35%)	762.89	0	438.44	0	288.35	23.9	1,051.24	23.90
	5.00%	21-27-**45** (30%)	637.74	0	836.72	0	558.73	20.27	1,196.47	20.27
	7.50%	21-26-**42** (35%)	762.89	0	866.03	0	473.00	16.69	1,235.89	16.69
	10.00%	21-26-**40** (35%)	762.89	0	866.03	0	631.39	14.37	1,394.28	14.37
	12.50%	21-27-**38** (35%)	762.89	0	921.95	0	872.77	11.62	1,635.66	11.62
	15.00%	21-27-**38** (35%)	762.89	0	921.95	0	872.77	11.62	1,635.66	11.62
90	2.50%	19-51-**59** (35%)	767.78	0	410.65	8.77	318.56	27.74	1,086.34	36.51
	5.00%	19-24-**42** (30%)	635.16	0	850.66	0	627.64	21.68	1,262.80	21.68
	7.50%	19-24-**41** (30%)	635.16	0	850.66	0	708.88	20.38	1,344.04	20.38
	10.00%	19-24-**37** (35%)	767.78	0	934.71	0	710.94	14.83	1,478.72	14.83
	12.50%	19-24-**37** (35%)	767.78	0	934.71	0	710.94	14.83	1,478.72	14.83
	15.00%	19-24-**37** (35%)	767.78	0	934.71	0	710.94	14.83	1,478.72	14.83

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]**Indicates no operation conducted.**

Table 18. Volume removed from the financially optimal schedules for loblolly pine plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	22-**60**[3] (35%)[4]	569.77	0	-[5]	-	544.51	28.13	1,114.28	28.13
	5.00%	23-29-**48** (30%)	624.69	0	750.70	0	500.76	18.8	1,876.15	18.80
	7.50%	23-29-**48** (30%)	624.69	0	750.70	0	500.76	18.8	1,876.15	18.80
	10.00%	23-30-**44** (35%)	745.28	0	875.58	0	433.68	14.44	1,178.96	14.44
	12.50%	23-28-**43** (35%)	745.28	0	780.81	0	588.09	13.27	1,333.37	13.27
	15.00%	23-28-**41** (35%)	745.28	0	780.81	0	870.08	10.56	1,615.36	10.56
80	2.50%	21-55-**60** (35%)	762.89	0	338.45	8.62	286.49	24.06	1,049.38	32.68
	5.00%	21-27-**45** (30%)	637.74	0	836.72	0	558.73	20.27	1,196.47	20.27
	7.50%	22-27-**43** (30%)	761.84	0	822.60	0	745.18	17.64	1,507.02	17.64
	10.00%	22-27-**40** (35%)	896.93	0	905.52	0	581.63	14.23	1,478.56	14.23
	12.50%	21-27-**38** (35%)	762.89	0	921.95	0	872.77	11.62	1,635.66	11.62
	15.00%	21-27-**38** (35%)	762.89	0	921.95	0	872.77	11.62	1,635.66	11.62
90	2.50%	19-51-**59** (35%)	767.78	0	410.65	8.77	318.56	27.74	1,086.34	36.51
	5.00%	22-28-**44** (25%)	765.95	0	898.35	0	736.86	22.58	1,502.81	22.58
	7.50%	19-24-**41** (35%)	635.16	0	850.66	0	708.88	20.38	1,344.04	20.38
	10.00%	19-24-**37** (35%)	767.78	0	934.71	0	710.94	14.83	1,478.72	14.83
	12.50%	19-24-**37** (35%)	767.78	0	934.71	0	710.94	14.83	1,478.72	14.83
	15.00%	19-24-**37** (35%)	767.78	0	934.71	0	710.94	14.83	1,478.72	14.83

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for loblolly pine plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	22-**60**[3] (35%)[4]	569.77	0	-[5]	-	544.51	28.13	1,114.28	28.13
	5.00%	23-29-**49** (30%)	624.69	0	750.70	0	489.65	19.64	1,865.04	19.64
	7.50%	23-33-**48** (30%)	624.69	0	922.11	0	531.98	18.26	2,078.78	18.26
	10.00%	25-35-**46** (30%)	771.31	0	968.37	0	677.43	15.46	1,448.74	15.46
	12.50%	25-32-**45** (25%)	641.64	0	744.26	0	1,271.59	13.8	1,913.23	13.80
	15.00%	25-32-**45** (25%)	641.64	0	744.26	0	1,271.59	13.8	1,913.23	13.80
80	2.50%	21-55-**60** (35%)	762.89	0	338.45	8.62	286.49	24.05	1,049.38	32.68
	5.00%	22-28-**49** (25%)	628.46	0	764.71	0	591.95	23.49	1,220.41	23.49
	7.50%	21-30-**44** (30%)	637.74	0	987.61	0	641.13	18.79	1,278.87	18.79
	10.00%	23-30-**43** (30%)	819.83	0	954.80	0	675.16	17.28	1,494.99	17.28
	12.50%	24-31-**42** (30%)	864.64	0	991.95	0	767.63	15.69	1,632.27	15.69
	15.00%	25-34-**40** (35%)	1,075.31	0	1,234.09	0	564.58	12.71	1,639.89	12.71
90	2.50%	19-53-**60** (30%)	635.16	0	439.35	7.64	377.62	30.09	1,012.78	37.73
	5.00%	19-24-**42** (30%)	635.16	0	850.66	0	627.64	21.68	1,262.80	21.68
	7.50%	19-24-**42** (30%)	635.16	0	850.66	0	627.64	21.68	1,262.80	21.68
	10.00%	21-30-**41** (30%)	851.51	0	1,146.92	0	626.20	19.23	1,477.71	19.23
	12.50%	22-30-**39** (30%)	926.91	0	1,137.74	0	945.33	15.86	1,872.24	15.86
	15.00%	22-30-**39** (30%)	926.91	0	1,137.74	0	945.33	15.86	1,872.24	15.86

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for loblolly pine plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	22-**60**[3] (35%)[4]	569.77	0	-[5]	-	544.51	28.13	1,114.28	28.13
	5.00%	24-30-**53** (25%)	617.33	0	684.90	0	525.97	22.42	1,828.20	22.42
	7.50%	28-36-**49** (25%)	724.98	0	834.00	0	674.28	18.29	2,233.26	18.29
	10.00%	29-34-**47** (25%)	758.55	0	775.53	0	972.52	15.89	2,506.60	15.89
	12.50%	32-38-**47** (30%)	1,038.07	0	1,007.79	0	455.30	15.64	2,501.16	15.64
	15.00%	40-**48** (35%)	1,581.06	0	-	-	1,423.45	13.69	3,004.51	13.69
80	2.50%	21-54-**60** (30%)	637.74	0	540.32	6.16	348.42	26.30	1,526.48	32.46
	5.00%	22-28-**49** (25%)	628.46	0	764.71	0	591.95	23.49	1,985.12	23.49
	7.50%	28-33-**47** (25%)	880.95	0	894.67	0	626.70	20.88	2,402.32	20.88
	10.00%	26-31-**45** (25%)	797.15	0	847.27	0	956.89	18.50	2,601.31	18.50
	12.50%	38-**44** (35%)	1,780.68	0	-	-	1,594.93	13.99	3,375.61	13.99
	15.00%	39-**44** (35%)	1,830.02	0	-	-	1,568.76	13.79	3,398.78	13.79
90	2.50%	19-53-**60** (30%)	635.16	0	439.35	7.64	377.62	30.09	1,452.13	37.73
	5.00%	19-28-**43** (30%)	635.16	0	1,080.31	0	619.72	22.12	2,335.19	22.12
	7.50%	25-30-**44** (25%)	909.22	0	949.95	0	665.65	22.28	2,524.82	22.28
	10.00%	25-31-**43** (25%)	909.22	0	987.90	0	744.66	20.99	2,641.78	20.99
	12.50%	26-31-**41** (30%)	1,154.32	0	1,128.86	0	581.53	18.16	2,864.71	18.16
	15.0%	36-**43** (35%)	1,965.33	0	-	-	1,511.31	16.89	3,476.64	16.89

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for loblolly pine plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	22-**60**[2] (35%)[3]	22-**60** (35%)	0%	22-**60** (35%)	0%	22-**60** (35%)	0%
	80	21-53-**59** (35%)	21-55-**60** (35%)	2%	21-55-**60** (35%)	2%	21-54-**60** (30%)	2%
	90	19-51-**59** (35%)	19-51-**59** (35%)	0%	19-53-**60** (30%)	2%	19-53-**60** (30%)	2%
5.00%	70	23-29-**48** (30%)	23-29-**48** (30%)	0%	23-29-**49** (30%)	2%	24-30-**53** (25%)	10%
	80	21-27-**45** (30%)	21-27-**45** (30%)	0%	22-28-**49** (25%)	9%	22-28-**49** (25%)	9%
	90	19-24-**42** (30%)	22-28-**44** (25%)	5%	19-24-**42** (30%)	0%	19-28-**43** (30%)	2%
7.50%	70	<23-30-**44**>[4] (35%)	23-29-**48** (30%)	9%	23-33-**48** (30%)	9%	28-36-**49** (25%)	11%
	80	<21-26-**42**> (35%)	21-27-**45** (30%)	7%	21-30-**44** (30%)	5%	28-33-**47** (25%)	12%
	90	19-24-**41** (30%)	19-24-**41** (30%)	0%	19-24-**42** (30%)	2%	25-30-**44** (25%)	7%
10.00%	70	<23-28-**43**> (35%)	<23-30-**44**> (35%)	2%	25-35-**46** (30%)	7%	29-34-**47** (25%)	9%
	80	<21-26-**40**> (35%)	<22-27-**40**> (35%)	0%	23-30-**43** (30%)	8%	26-31-**45** (25%)	13%
	90	<19-24-**37**> (35%)	19-24-**37** (35%)	0%	21-30-**41** (30%)	11%	25-31-**43** (25%)	16%
12.50%	70	<23-28-**43**> (35%)	<23-28-**43**> (35%)	0%	25-32-**45** (25%)	5%	32-38-**47** (30%)	9%
	80	<21-27-**38**> (35%)	<22-27-**40**> (35%)	5%	24-31-**42** (30%)	11%	38-**44** (35%)	16%
	90	<19-24-**37**> (35%)	<19-24-**37**> (35%)	0%	22-30-**39** (30%)	5%	26-31-**41** (30%)	11%
15.00%	70	<23-28-**41**> (35%)	<23-28-**41**> (35%)	0%	<25-32-**45**> (25%)	10%	40-**48** (35%)	17%
	80	<21-27-**38**> (35%)	<21-27-**38**> (35%)	0%	25-34-**40** (35%)	5%	39-**44** (35%)	16%
	90	<19-24-**37**> (35%)	<19-24-**37**> (35%)	0%	22-30-**39** (30%)	5%	36-**43** (35%)	16%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning
[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for loblolly pine plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	2,640.78	3,071.81	16%	4,235.59	60%	4,795.93	82%
	80	3,267.39	3,768.27	15%	5,125.54	57%	5,784.39	77%
	90	3,887.34	4,466.57	15%	6,053.86	56%	6,827.54	76%
5.00%	70	370.74	583.05	57%	1,159.07	213%	1,441.04	289%
	80	550.67	800.75	45%	1,479.76	169%	1,819.86	230%
	90	769.93	1,011.75	31%	1,837.07	139%	2,220.08	188%
7.50%	70	-95.13	43.38		430.59		619.48	
	80	-17.81	147.28		612.30		838.38	
	90	73.44	272.61	271%	811.14	1004%	1,077.78	1368%
10.00%	70	-226.62	-124.24		157.41		298.49	
	80	-189.93	-65.66		277.53		447.49	
	90	-145.00	1.24		407.89		611.15	
12.50%	70	-271.25	-190.75		29.66		139.02	
	80	-252.65	-153.62		117.90		252.77	
	90	-229.46	-111.30		213.78		374.99	
15.00%	70	-286.43	-221.02		-42.27		46.10	
	80	-276.86	-195.05		27.93		139.26	
	90	-265.00	-166.40		104.03		238.18	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

Southern- Loblolly Pine - Timber Only Rotations (C = $0/ton)

Loblolly Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 22 (with 35 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 5). This optimal management regime will generate the maximum SEV of $2,640.78 (Table 13), with a NPW of $2,055.21 per acre (Table 9). This means that $2,640.78 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,055.21 per acre for managing one rotation, or $2,640.78 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 1,114.28 cubic feet of pulpwood and 28.13 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 51.03 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Loblolly Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 23 and 29 (with 30 percent of basal area removed) and a final harvest at stand age 48 is conducted (Table 5). This optimal management regime will generate the maximum SEV of $370.74 (Table 13), with a NPW of $336.79 per acre (Table 9). This financially optimal rotation could

produce an estimated 1,876.15 cubic feet of pulpwood and 28.13 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 40.28 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 23 and 30 (with 35 percent of basal area removed) and a final harvest at stand age 44 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$95.13 (Table 13), with a NPW of -$91.40 per acre (Table 9). This financially optimal rotation could produce an estimated 2,054.24 cubic feet of pulpwood and 14.44 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 35.16 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 23 and 28 (with 35 percent of basal area removed) and a final harvest at stand age 43 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$226.62 (Table 13), with a NPW of -$223.20 per acre (Table 9). This financially optimal rotation could produce an estimated 2,114.18 cubic feet of pulpwood and 13.27 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 33.92 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 23 and 28 (with 35 percent of basal area removed) and a final harvest at stand age 43 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$271.25 (Table 13), with a NPW of -$269.73 per acre (Table 9). This financially optimal rotation could produce an estimated 2,114.18 cubic feet of pulpwood and 13.27 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 33.92 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 23 and 28 (with 35 percent of basal area removed) and a final harvest at stand age 41 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$286.43 (Table 13), with a NPW of -$285.62 per acre (Table 9). This financially optimal rotation could produce an estimated 2,396.17 cubic feet of pulpwood and 10.56 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 32.15 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 21 and 53 (with 35 percent of basal area removed) and a final harvest at stand age 59 is conducted (Table 5). This optimal management regime will generate the maximum SEV of $3,267.39 (Table 13), with a NPW of $2,524.77 per acre (Table 9). This financially optimal rotation could

produce an estimated 1,489.68 cubic feet of pulpwood and 23.90 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 58.10 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 21 and 27 (with 30 percent of basal area removed) and a final harvest at stand age 45 is conducted (Table 5). This optimal management regime will generate the maximum SEV of $550.67 (Table 13), with a NPW of $492.30 per acre (Table 9). This financially optimal rotation could produce an estimated 2,033.19 cubic feet of pulpwood and 20.27 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 43.82 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 21 and 26 (with 35 percent of basal area removed) and a final harvest at stand age 42 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$17.81 (Table 13), with a NPW of -$17.02 per acre (Table 9). This financially optimal rotation could produce an estimated 2,101.92 cubic feet of pulpwood and 16.69 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 38.75 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 21 and 26 (with 35 percent of basal area removed) and a final harvest at stand age 40 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$189.93 (Table 13), with a NPW of -$186.11 per acre (Table 9). This financially optimal rotation could produce an estimated 2,260.31 cubic feet of pulpwood and 14.37 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 36.72 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 21 and 27 (with 35 percent of basal area removed) and a final harvest at stand age 38 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$252.65 (Table 13), with a NPW of -$250.10 per acre (Table 9). This financially optimal rotation could produce an estimated 2,557.61 cubic feet of pulpwood and 11.62 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 34.94 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 21 and 27 (with 35 percent of basal area removed) and a final harvest at stand age 38 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$276.86 (Table 13), with a NPW of -$275.67 per acre (Table 9). This financially optimal rotation could

produce an estimated 2,557.61 cubic feet of pulpwood and 11.62 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 34.94 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 19 and 51 (with 35 percent of basal area removed) and a final harvest at stand age 59 is conducted (Table 5). This optimal management regime will generate the maximum SEV of $3,887.34 (Table 13), with a NPW of $3,003.81 per acre (Table 9). This financially optimal rotation could produce an estimated 1,496.99 cubic feet of pulpwood and 36.51 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 66.98 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 29 and 24 (with 30 percent of basal area removed) and a final harvest at stand age 42 is conducted (Table 5). This optimal management regime will generate the maximum SEV of $769.93 (Table 13), with a NPW of $675.46 per acre (Table 9). This financially optimal rotation could produce an estimated 2,113.46 cubic feet of pulpwood and 21.68 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 47.11 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 19 and 24 (with 30 percent of basal area removed) and a final harvest at stand age 41 is conducted (Table 5). This optimal management regime will generate the maximum SEV of $73.44 (Table 13), with a NPW of $69.92 per acre (Table 9). This financially optimal rotation could produce an estimated 2,194.70 cubic feet of pulpwood and 20.38 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 45.79 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 19 and 24 (with 35 percent of basal area removed) and a final harvest at stand age 37 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$145.00 (Table 13), with a NPW of -$141.12 per acre (Table 9). This financially optimal rotation could produce an estimated 2,413.43 cubic feet of pulpwood and 14.83 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 38.96 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 19 and 24 (with 35 percent of basal area removed) and a final harvest at stand age 37 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$229.46 (Table 13), with a NPW of -$226.85 per acre (Table 9). This financially optimal rotation could

produce an estimated 2,413.43 cubic feet of pulpwood and 14.83 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 38.96 net tons of carbon per acre during one rotation (Table 1).

Loblolly Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 19 and 24 (with 35 percent of basal area removed) and a final harvest at stand age 37 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$265.00 (Table 13), with a NPW of -$263.69 per acre (Table 9). This financially optimal rotation could produce an estimated 2,413.43 cubic feet of pulpwood and 14.83 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 38.96 net tons of carbon per acre during one rotation (Table 1).

Southern- Loblolly Pine - Timber Only Rotations (C = $10/ton)

Loblolly Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 22 (with 35 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $3,071.81 (Table 14), with a NPW of $2,390.67 per acre (Table 10). This means that $3,071.81 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,390.67 per acre for managing one rotation, or $3,071.81 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 1,114.28 cubic feet of pulpwood and 28.13 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 51.03 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Loblolly Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 23 and 29 (with 30 percent of basal area removed) and a final harvest at stand age 48 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $583.05 (Table 14), with a NPW of $529.66 per acre (Table 10). This financially optimal rotation could produce an estimated 1,876.15 cubic feet of pulpwood and 18.80 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.28 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 23 and 29 (with 35 percent of basal area removed) and a final harvest at stand age 48 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $43.38 (Table 14), with a NPW of $42.13 per acre (Table 10). This financially optimal rotation could produce an estimated 1,876.15 cubic feet of pulpwood and 18.80 MBF of sawlogs per acre from the

thinning and final harvest (Table 18), and sequester 40.28 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 23 and 30 (with 35 percent of basal area removed) and a final harvest at stand age 44 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$124.24 (Table 14), with a NPW of -$122.54 per acre (Table 10). This financially optimal rotation could produce an estimated 2,054.54 cubic feet of pulpwood and 14.44 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 35.16 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 23 and 28 (with 35 percent of basal area removed) and a final harvest at stand age 43 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$190.75 (Table 14), with a NPW of -$189.68 per acre (Table 10). This financially optimal rotation could produce an estimated 2,114.18 cubic feet of pulpwood and 13.27 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 33.92 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 23 and 28 (with 35 percent of

basal area removed) and a final harvest at stand age 41 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$221.02 (Table 14), with a NPW of -$220.39 per acre (Table 10). This financially optimal rotation could produce an estimated 2,396.17 cubic feet of pulpwood and 10.56 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 32.15 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 21 and 55 (with 35 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $3,768.27 (Table 14), with a NPW of $2,932.70 per acre (Table 10). This financially optimal rotation could produce an estimated 1,387.83 cubic feet of pulpwood and 32.68 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 59.18 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 21 and 27 (with 30 percent of basal area removed) and a final harvest at stand age 45 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $800.75 (Table 14), with a NPW of $715.87 per acre (Table 10). This financially optimal rotation could produce an estimated 2,033.19 cubic feet of pulpwood and 20.27 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 43.82 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 22 and 27 (with 30 percent of basal area removed) and a final harvest at stand age 43 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $147.28 (Table 14), with a NPW of $141.17 per acre (Table 10). This financially optimal rotation could produce an estimated 2,329.62 cubic feet of pulpwood and 17.64 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 41.50 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 22 and 27 (with 35 percent of basal area removed) and a final harvest at stand age 40 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$65.66 (Table 14), with a NPW of -$64.34 per acre (Table 10). This financially optimal rotation could produce an estimated 2,384.08 cubic feet of pulpwood and 14.23 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 36.76 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 21 and 27 (with 35 percent of

basal area removed) and a final harvest at stand age 38 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$153.62 (Table 14), with a NPW of -$152.07 per acre (Table 10). This financially optimal rotation could produce an estimated 2,557.61 cubic feet of pulpwood and 11.62 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 34.94 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 21 and 27 (with 35 percent of basal area removed) and a final harvest at stand age 38 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$195.05 (Table 14), with a NPW of -$194.21 per acre (Table 10). This financially optimal rotation could produce an estimated 2,557.61 cubic feet of pulpwood and 11.62 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 34.94 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 19 and 51 (with 35 percent of basal area removed) and a final harvest at stand age 59 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $4,466.57 (Table 14), with a NPW of $3,451.39 per acre (Table 10). This financially optimal rotation could produce an estimated 1,496.99 cubic feet of pulpwood and 36.51 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 66.98 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 22 and 28 (with 25 percent of basal area removed) and a final harvest at stand age 44 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $1,011.75 (Table 14), with a NPW of $899.15 per acre (Table 10). This financially optimal rotation could produce an estimated 2,401.16 cubic feet of pulpwood and 22.58 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 50.04 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 19 and 24 (with 30 percent of basal area removed) and a final harvest at stand age 41 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $272.61 (Table 14), with a NPW of $259.54 per acre (Table 10). This financially optimal rotation could produce an estimated 2,194.70 cubic feet of pulpwood and 20.38 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 45.79 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 19 and 24 (with 35 percent of

basal area removed) and a final harvest at stand age 37 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $1.24 (Table 14), with a NPW of $1.21 per acre (Table 10). This financially optimal rotation could produce an estimated 2,413.43 cubic feet of pulpwood and 14.83 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 38.96 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 19 and 24 (with 35 percent of basal area removed) and a final harvest at stand age 37 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$111.30 (Table 14), with a NPW of -$110.03 per acre (Table 10). This financially optimal rotation could produce an estimated 2,413.43 cubic feet of pulpwood and 14.83 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 38.96 net tons of carbon per acre during one rotation (Table 2).

Loblolly Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 19 and 24 (with 35 percent of basal area removed) and a final harvest at stand age 37 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$166.40 (Table 14), with a NPW of -$165.58 per acre (Table 10). This financially optimal rotation could produce an estimated 2,413.43 cubic feet of pulpwood and 14.83 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 38.96 net tons of carbon per acre during one rotation (Table 2).

<u>Southern- Loblolly Pine - Timber Only Rotations (C = $37/ton)</u>

Loblolly Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 22 (with 35 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $4,235.59 (Table 15), with a NPW of $3,296.39 per acre (Table 11). This means that $4,235.59 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $3,296.39 per acre for managing one rotation, or $4,235.59 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 1,114.28 cubic feet of pulpwood and 28.13 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 51.03 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Loblolly Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 23 and 29 (with 30 percent of basal area removed) and a final harvest at stand age 49 is conducted (Table 7). This

optimal management regime will generate the maximum SEV of $1,159.07 (Table 15), with a NPW of $1,058.00 per acre (Table 11). This financially optimal rotation could produce an estimated 1,865.04 cubic feet of pulpwood and 19.64 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 41.35 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 23 and 33 (with 30 percent of basal area removed) and a final harvest at stand age 48 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $430.59 (Table 15), with a NPW of $418.14 per acre (Table 11). This financially optimal rotation could produce an estimated 2,078.78 cubic feet of pulpwood and 18.26 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.97 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 25 and 35 (with 30 percent of basal area removed) and a final harvest at stand age 46 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $157.41 (Table 15), with a NPW of $155.62 per acre (Table 11). This financially optimal rotation could produce an estimated 2,417.11 cubic feet of pulpwood and 15.46 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 38.92 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 25 and 32 (with 25 percent of basal area removed) and a final harvest at stand age 45 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $29.66 (Table 15), with a NPW of $29.53 per acre (Table 11). This financially optimal rotation could produce an estimated 2,657.49 cubic feet of pulpwood and 13.80 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 38.65 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 25 and 32 (with 25 percent of basal area removed) and a final harvest at stand age 45 is conducted (Table 7). This optimal management regime will generate the maximum SEV of -$42.27 (Table 15), with a NPW of -$42.20 per acre (Table 11). This financially optimal rotation could produce an estimated 2,657.49 cubic feet of pulpwood and 13.80 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 38.65 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 21 and 55 (with 35 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $5,125.54 (Table 15),

with a NPW of $3,989.00 per acre (Table 11). This financially optimal rotation could produce an estimated 1,387.83 cubic feet of pulpwood and 32.68 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 59.18 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 22 and 28 (with 25 percent of basal area removed) and a final harvest at stand age 49 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $1,479.76 (Table 15), with a NPW of $1,305.72 per acre (Table 11). This financially optimal rotation could produce an estimated 1,985.12 cubic feet of pulpwood and 23.49 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 48.13 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 21 and 30 (with 30 percent of basal area removed) and a final harvest at stand age 44 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $612.30 (Table 15), with a NPW of $588.66 per acre (Table 11). This financially optimal rotation could produce an estimated 2,266.48 cubic feet of pulpwood and 18.79 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 43.36 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 23 and 30 (with 30 percent of basal area removed) and a final harvest at stand age 43 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $277.53 (Table 15), with a NPW of $273.35 per acre (Table 11). This financially optimal rotation could produce an estimated 2,449.79 cubic feet of pulpwood and 17.28 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 41.76 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 24 and 31 (with 30 percent of basal area removed) and a final harvest at stand age 42 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $117.90 (Table 15), with a NPW of $117.16 per acre (Table 11). This financially optimal rotation could produce an estimated 2,873.98 cubic feet of pulpwood and 12.71 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.87 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 25 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 40 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $27.93 (Table 15), with a NPW of $27.84 per acre (Table 11). This financially optimal rotation could produce an

estimated 2,873.98 cubic feet of pulpwood and 12.71 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 38.25 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 19 and 53 (with 30 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $6,053.86 (Table 15), with a NPW of $4,711.47 per acre (Table 11). This financially optimal rotation could produce an estimated 1,452.13 cubic feet of pulpwood and 37.73 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 69.55 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 19 and 24 (with 30 percent of basal area removed) and a final harvest at stand age 42 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $1,837.07 (Table 15), with a NPW of $1,611.65 per acre (Table 11). This financially optimal rotation could produce an estimated 2,113.46 cubic feet of pulpwood and 21.68 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 47.11 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 19 and 24 (with 30 percent of basal area removed) and a final harvest at stand age 42 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $811.14 (Table 15), with a NPW of $774.95 per acre (Table 11). This financially optimal rotation could produce an estimated 2,113.46 cubic feet of pulpwood and 21.68 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 47.11 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 21 and 30 (with 30 percent of basal area removed) and a final harvest at stand age 41 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $407.89 (Table 15), with a NPW of $400.44 per acre (Table 11). This financially optimal rotation could produce an estimated 2,624.63 cubic feet of pulpwood and 19.23 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 46.42 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 22 and 30 (with 30 percent of basal area removed) and a final harvest at stand age 39 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $213.78 (Table 15), with a NPW of $211.86 per acre (Table 11). This financially optimal rotation could

produce an estimated 3,009.98 cubic feet of pulpwood and 15.86 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 44.08 net tons of carbon per acre during one rotation (Table 3).

Loblolly Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 22 and 30 (with 30 percent of basal area removed) and a final harvest at stand age 39 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $104.03 (Table 15), with a NPW of $103.65 per acre (Table 11). This financially optimal rotation could produce an estimated 3,009.98 cubic feet of pulpwood and 15.86 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 44.08 net tons of carbon per acre during one rotation (Table 3).

Southern- Loblolly Pine - Timber Only Rotations (C = $50/ton)

Loblolly Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 22 (with 35 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $4,795.93 (Table 16), with a NPW of $3,732.48 per acre (Table 12). This means that $4,795.93 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $3,732.48 per acre for managing one rotation, or $4,795.93 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 1,114.28 cubic feet of pulpwood and 28.13 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 51.03 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Loblolly Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 24 and 30 (with 25 percent of basal area removed) and a final harvest at stand age 53 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $1,441.04 (Table 16), with a NPW of $1,337.65 per acre (Table 12). This financially optimal rotation could produce an estimated 1,828.20 cubic feet of pulpwood and 22.42 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 44.98 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 28 and 36 (with 25 percent of basal area removed) and a final harvest at stand age 49 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $649.48 (Table 16), with a NPW of $602.82 per acre (Table 12). This financially optimal rotation could produce an estimated 2,233.26 cubic feet of pulpwood and 18.29 MBF of sawlogs per

acre from the thinning and final harvest (Table 20), and sequester 42.15 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 29 and 34 (with 25 percent of basal area removed) and a final harvest at stand age 47 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $298.49 (Table 16), with a NPW of $295.41 per acre (Table 12). This financially optimal rotation could produce an estimated 2,506.60 cubic feet of pulpwood and 15.89 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.57 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 32 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 47 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $139.02 (Table 16), with a NPW of $138.54 per acre (Table 12). This financially optimal rotation could produce an estimated 2,501.16 cubic feet of pulpwood and 15.64 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 39.95 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area

removed) and a final harvest at stand age 48 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $46.10 (Table 16), with a NPW of $46.05 per acre (Table 12). This financially optimal rotation could produce an estimated 3,004.51 cubic feet of pulpwood and 13.69 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 41.62 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 21 and 54 (with 30 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $5,784.39 (Table 16), with a NPW of $4,501.76 per acre (Table 12). This financially optimal rotation could produce an estimated 1,526.48 cubic feet of pulpwood and 32.46 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 60.23 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 22 and 28 (with 25 percent of basal area removed) and a final harvest at stand age 49 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $1,819.86 (Table 16), with a NPW of $1,661.16 per acre (Table 12). This financially optimal rotation could produce an estimated 1,985.12 cubic feet of pulpwood and 23.49 MBF of sawlogs per

acre from the thinning and final harvest (Table 20), and sequester 48.13 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 28 and 33 (with 25 percent of basal area removed) and a final harvest at stand age 47 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $838.38 (Table 16), with a NPW of $812.33 per acre (Table 12). This financially optimal rotation could produce an estimated 2,402.32 cubic feet of pulpwood and 20.88 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 47.04 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 26 and 31 (with 25 percent of basal area removed) and a final harvest at stand age 45 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $447.49 (Table 16), with a NPW of $441.91 per acre (Table 12). This financially optimal rotation could produce an estimated 2,601.31 cubic feet of pulpwood and 18.50 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 44.92 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 38 (with 35 percent of basal area

removed) and a final harvest at stand age 44 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $252.77 (Table 16), with a NPW of $251.50 per acre (Table 12). This financially optimal rotation could produce an estimated 3,375.61 cubic feet of pulpwood and 13.99 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 44.62 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 39 (with 35 percent of basal area removed) and a final harvest at stand age 44 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $139.26 (Table 16), with a NPW of $139.01 per acre (Table 12). This financially optimal rotation could produce an estimated 3,398.78 cubic feet of pulpwood and 13.79 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 38.25 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 19 and 53 (with 30 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $6,827.54 (Table 16), with a NPW of $5,313.60 per acre (Table 12). This financially optimal rotation could produce an estimated 1,452.13 cubic feet of pulpwood and 37.73 MBF of sawlogs per

acre from the thinning and final harvest (Table 20), and sequester 69.55 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 19 and 28 (with 30 percent of basal area removed) and a final harvest at stand age 43 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $2,220.08 (Table 16), with a NPW of $1,960.64 per acre (Table 12). This financially optimal rotation could produce an estimated 2,335.19 cubic feet of pulpwood and 22.12 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 49.35 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 25 and 30 (with 25 percent of basal area removed) and a final harvest at stand age 44 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $1,077.78 (Table 16), with a NPW of $1,036.17 per acre (Table 12). This financially optimal rotation could produce an estimated 2,524.82 cubic feet of pulpwood and 22.28 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 50.44 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 25 and 31 (with 25 percent of

basal area removed) and a final harvest at stand age 43 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $611.15 (Table 16), with a NPW of $601.93 per acre (Table 12). This financially optimal rotation could produce an estimated 2,641.78 cubic feet of pulpwood and 20.99 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 49.34 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 26 and 31 (with 30 percent of basal area removed) and a final harvest at stand age 41 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $374.99 (Table 16), with a NPW of $372.32 per acre (Table 12). This financially optimal rotation could produce an estimated 2,864.71 cubic feet of pulpwood and 18.16 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 46.37 net tons of carbon per acre during one rotation (Table 4).

Loblolly Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 36 (with 35 percent of basal area removed) and a final harvest at stand age 43 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $238.18 (Table 16), with a NPW of $237.67 per acre (Table 12). This financially optimal rotation could produce an estimated 3,476.64 cubic feet of pulpwood and 16.89 MBF of sawlogs per acre from the

thinning and final harvest (Table 20), and sequester 50.07 net tons of carbon per acre during one rotation (Table 4).

Lodgepole Pine (*Pinus contorta* Dougl. ex. Loud.)

Biological information

Lodgepole pine is a two-needled pine that is common in western North America. There are four varieties of this species: *Pinus contorta* subsp. *contorta* var. *contorta* (also known as Shore Pine, coast pine, or beach pine); *Pinus contorta* subsp. *contorta* var. *bolanderi* (or Bolander Pine); *Pinus contorta* subsp. *murrayana* (Tamarack Pine or Sierra Lodgepole Pine) and *Pinus contorta* subsp. *latifolia* (Rocky Mountain Lodgepole Pine or Black pine). Lodgepole pine is adapted to high mountain slopes at elevations usually above 6,000 feet. The coastal form grows mainly between sea level and 2,000 ft, the inland form grows commonly from 1,600 to 12,000ft. (Silvics manual, USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/Volume_1/pinus/contorta.htm. May 28, 2006).

Lodgepole pine is found throughout the Rocky Mountain and Pacific coast regions, extending north to the Yukon Territory and south to California, and west to east from the Pacific ocean to South Dakota (Silvics manual, USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/Volume_1/pinus/contorta.htm. May 28, 2006) (Fig. 1).

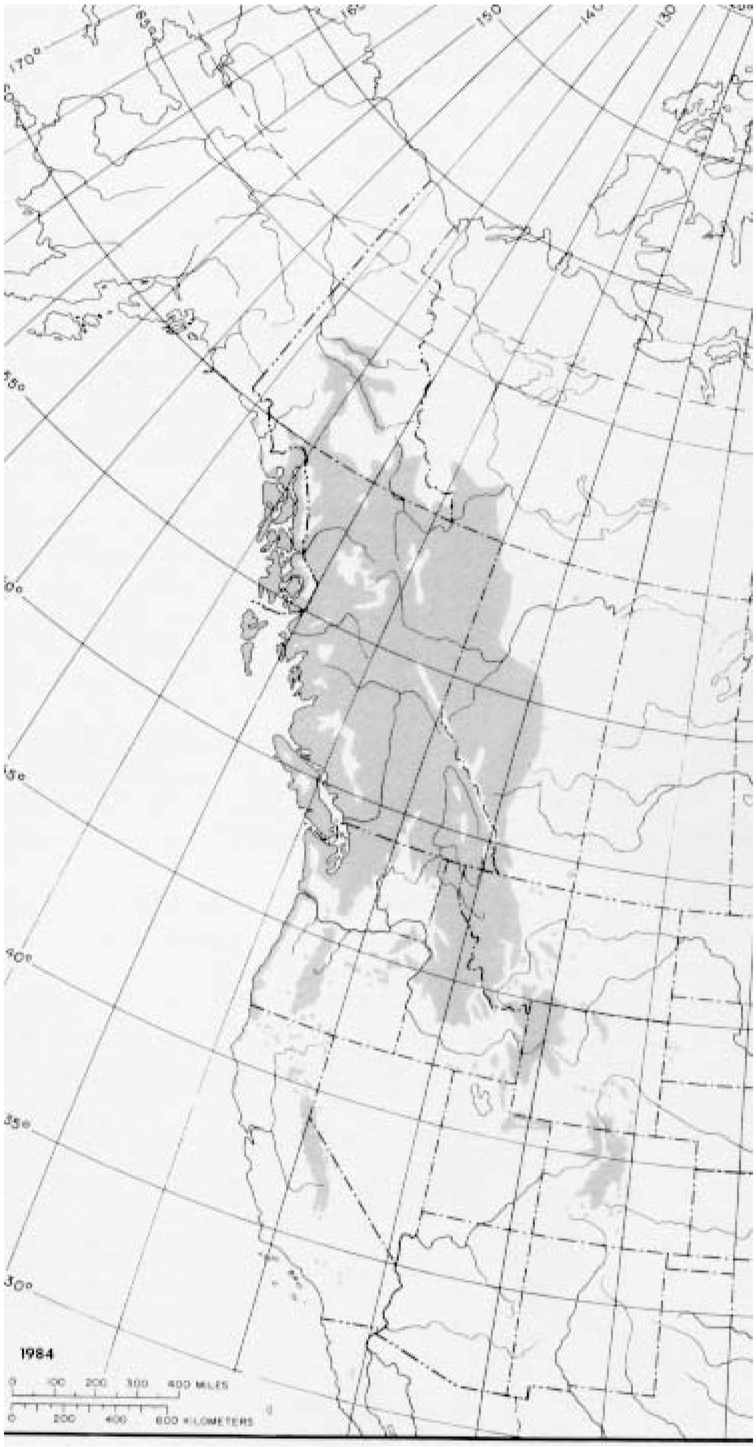

Fig. 1. The Native range of Lodgepole pine (Silvics manual, USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/Volume_1/pinus/contorta.htm. May 28, 2006).

Stand density and environment factors have a great influence on the growth and yield of lodgepole pine. In the Rocky Mountain, the maximum yield was 20,000

MBF/acre with a planting density of 800 trees/acre but the yield dropped to 1,500 MBF/acre at a density of 1,800 tree/acre. Under good site quality and without the disturbance of mountain pine beetle and dwarf mistletoe, yields can reach 24,000 MBF/acre (Silvics manual, USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/Volume_1/pinus/contorta.htm. May 28, 2006).

Mature sizes vary greatly between stands and different regions. In the Rocky mountains, most 140 years old mature trees reach heights of 60 to 80 ft., and 7 to 13 in. in d.b.h. In the Blue Mountains of Oregon, trees at 100 years of age were about 75 ft tall and 12 in. in d.b.h. Sierra lodgepole pines at the same age can reach a height of 90 to 100 ft with a diameter growth of 16 to 17 inches. Coastal trees and dwarf lodgepole, however, are much smaller. Coastal trees are commonly found 20 to 40 ft tall and Dwarf trees are only about 2 to 5 ft. (Silvics manual, USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/Volume_1/pinus/contorta.htm. May 28, 2006).

Lodgepole pine responds very well to thinning operations. Control of stand density contributes greatly to increasing productivity and redirects the young stands into merchantable-size product (Silvics manual, USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/Volume_1/pinus/contorta.htm. May 28, 2006).

As an important source of timber, lodgepole pine is used for framing, paneling, posts, corral poles, utility poles, railroad ties, and pulpwood. Lodgepole pine is important to animals for cover and habitat. It is also a major tree cover in recreational areas and on critical watersheds (Silvics manual, USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/Volume_1/pinus/contorta.htm. May 28, 2006).

Economic information

Ghebremichael et al. (2005) conducted an economic analysis to determine the growth response to thinning and fertilization of lodgepole pine in Alberta, Canada. Eight combinations of thinning and fertilization treatments were applied to 40-year-old natural stands. A simple factorial analysis of variance (ANOVA) was performed in 72 (4 levels of nitrogen fertilization × 2 thinning levels × 9 replications) plots in 1984. The economic profitability of the treatments was analyzed by calculating the soil expectation value (SEV), net present worth (NPW), benefit/cost ratio (BCR), and the internal rate of return (IRR) for real discount rate of 6, 8 and 10%. Statistical analyses of volume growth were conducted in the 10^{th} and 15^{th} year, and a projection of profitability 50 years after the experiment was initiated. The result of this study shows that fertilization and thinning significantly improved volume growth, and that thinning without fertilization had the greatest economic return.

Yang (1998) studied the foliage and stand growth response of lodgepole pine to thinning and nitrogen fertilization in mid-rotation stands by determining the optimum thinning and fertilizer regime. Treatments with two thinning intensities (thinned and unthinned control) and four nitrogen levels were performed. Foliage and soil were collected from the treated buffer for 4 years, and the diameter of all crop trees were measured every 5 years. Results of this study indicated that interactions between fertilization and thinning were not significant, and thinning did not affect needle mass until 3years after fertilization. The effect of fertilization disappeared 2 years after N treatment. Thinning significantly affected height increment, diameter growth and stand basal area and total volume.

Ondro and Constantino (1990) conducted experiments in fully-stocked 70-year old lodgepole pine stands 10 years before final harvest on two different soils (Coalspur and Mercoal) in Alberta to determine the financial returns from fertilization. Net present worth (NPW) and internal rate of return (IRR) were calculated to identify profitable fertilization treatments, and the NPW were used to rank the profitable treatments. The author indicated that fertilization of lodgepole pine stands 10 years before final harvest on Coalspur Mercoal soils in Alberta increased wood yield and reduced logging costs. The financial returns from these treatments suggest that fertilization in Alberta is a viable practice in the stands examined because of increased wood yield and reduction in logging costs. IRR may be as high as 11.7% on Coalspur soils and 16.3% on Mercoal soils.

Hooser and Keegan (1984) studied lodgepole pine as a commercial resource in the United States. The historic use, current use, and its regional, national and local output trends were researched in this paper. The economic importance of lodgepole pine in the western United States was highly recognized. Similarly, Kennedy (1984) conducted a research in lodgepole pine as a commercial resource in Canada. Data on the annual harvest from 1973 to 1982 of lodgepole pine industry in Alberta, Canada was collected, and stumpage price information in 1983 was provided. The author summarized the major uses of lodgepole pine in B.C. and Alberta in Canada and concluded that it has a critical commercial significance in Canada.

Ince (1982) performed an economic analysis to evaluate the practicality and potential for harvesting and utilizing small, dead lodgepole pine. A case study was conducted during a 3-month period in 1979, on six sites that totaled over 130 acres to demonstrate the harvest cost of small diameter, dead lodgepole trees. The results of the research indicated that 1) the costs of harvesting both roundwood and chips were lower and more variable than the cost of harvesting only chips, 2) however, it was also found that market prices for roundwood and chips are different and vary over time, 3) small, dead timer is also acceptable for primary products and physical properties do no create major harvest problems, 4) the recoverable heat energy produced from small, dead timber is about 15 times the energy input, 5) the cost-to-energy-value ratio of harvested and delivered small, dead timber was less than the price-to-energy-ratio of oil or gas but not coal.

Benson and Strong (1977) studied the wood product potential in mature lodgepole pine stands in Montana's Bitterroot National Forest. Statistic data on area and volume of mature trees were collected and products were graded to determine the potential of utilization for different wood class. Economic studies were also conducted to evaluate the market value of lodgepole trees. Some recommendations were given to offset the high input costs and to get positive harvesting revenue. The author concluded that two-thirds of the lodgepole stands on the Bitterroot National Forest were suited for high value, solid products and another 20% were suited for fiber. If harvest was well scheduled, roads were well constructed, and market conditions and wood prices were well studied, the utilization of lodgepole pine would be enhanced and economic returns would be increased.

Schweitzer (1975) performed an economic analysis on the economics of producing lodgepole pine stumpage in natural stands. Relationships between growth and yield and costs, discount stumpage values and rotation length, and other factors related to rotation length have been studied. The results of the study indicated that 1) felling and bucking costs dropped rapidly as tree size increased, and skidding costs dropped as the volumes harvested per acre increased, 2) management costs should only be spent on the most productive sites, 3) shortest rotations would generate the future income with greatest present value, 4) thinning did not affect the rotation length at very low interest rates, 5) and the relative advantages of spacing controls were more obvious at high discount rates.

Peterson and Giles (1988) conducted a research on resource management issues and direction being developed in Intermountain region for lodgepole pine. Four factors were studied: the political process, land management planning, current economic situation and biological factors. The information presented provided helpful guidance to the engineering, utilization, and economic aspects of lodgepole pine forest lands.

Benson (1986) presented an economic evaluation of alternative lodgepole pine stand effects on timber and nontimber resources in the Northern and Intermountain Forest Service Regions. Data from more than 30 treatment subunits in 15 areas were used in analyzing the economic and other management consequences of alternative harvesting practices. Statistical information for stand treatment and thinning costs, and product values were collected, and future timber values were projected. Net dollar values were calculated to determine the viability of different management alternatives. The results showed that some study areas that were well-stocked and demonstrated good diameter growth, where product revenue was high, and thinning and treatment costs were low enough, created a profitable or at least break-even future values. Other areas that were physically similar, but with higher treatment and thinning costs and lower timber value, had negative present values.

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Species Lodgepole pine Region Eastside Cascades

Site indices 70, 80 and 90 (base age 100), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 4.5-in. inside bark top diameter for trees with a minimum of 6 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 9-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 15 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.187943262 and 0.709219858, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Gower et al (1987) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Y = -1.143 + 2.449 \log X$$

where:

Y = component dry weight (kg)

X = stem diameter (cm)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.6% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $166/mbf (Scribner) (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices) and pulpwood price was assumed to be $0/cord (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of lodgepole pine plantations in the Eastside Cascades.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$80.28	Only once	Year 0	
Seedlings[b] (600 seedlings/ac)	$132	Only Once	Year 0	
Burning[a]	$21.24	Every 5 years	Year 10	Final Harvest
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al (2005).

[b]The seedling cost was estimated based on the seedling prices from Washington State DNR Webster Forest Nursery (http://www3.wadnr.gov/dnrapp3/webster/price.jsp.February 10, 2006) and Source of Oregon Native Forest Tree Seedlings 2004-2005 by elevation (http://egov.oregon.gov/ODF/PRIVATE_FORESTS/docs/2004Catalog.pdf. February 12, 2006).

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Table 1. Total tons of carbon sequestered per acre for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	18.08	14.49	14.76	13.99	13.45	12.90
80	18.89	17.65	14.25	15.78	13.35	13.35
90	17.43	15.09	14.80	14.41	13.55	13.55

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	18.08	14.49	14.30	13.99	13.99	13.45
80	18.89	17.65	14.25	13.95	13.95	13.35
90	18.43	15.09	14.99	14.12	13.55	13.55

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	18.08	14.49	14.49	14.30	13.99	13.99
80	18.53	18.43	14.51	15.73	14.15	13.95
90	18.88	18.16	14.60	14.12	14.12	13.91

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	18.08	14.49	14.49	14.49	14.30	13.99
80	18.53	18.43	14.51	14.25	14.25	14.15
90	18.88	18.16	14.60	14.60	14.12	14.12

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	<48-**89**[2]>[3] (30%)[4]	<**79**>	<60-**74**> (30%)	<**74**>	<**69**>	<**64**>
80	<45-**88**> (30%)	<41-**78**> (30%)	<**72**>	<41-**68**> (30%)	<**64**>	<**64**>
90	<68-84-**89**> (20%)	<68-**73**> (30%)	<61-**69**> (30%)	<56-**66**> (25%)	<**63**>	<**63**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	<48-**89**[2]>[3] (30%)[4]	<**79**>	<**77**>	<**74**>	<**74**>	<**69**>
80	<45-**88**> (30%)	<41-**78**> (30%)	<**72**>	<**69**>	<**69**>	<**64**>
90	<49-**84**> (25%)	<68-**73**> (30%)	<67-**72**> (30%)	<**68**>	<**63**>	<**63**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	48-**89**[2] (30%)[3]	<**79**>[4]	<**79**>	<**77**>	<**74**>	<**74**>
80	41-**84** (30%)	<41-**82**> (30%)	<**74**>	<64-**79**> (30%)	<**71**>	<**69**>
90	43-**84** (30%)	<37-**77**> (30%)	<**72**>	<**68**>	<**68**>	<**66**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s)
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	48-**89**[2] (30%)[3]	<**79**>[4]	<**79**>	<**79**>	<**77**>	<**74**>
80	41-**84** (30%)	<41-**82**> (30%)	<**74**>	<**72**>	<**72**>	<**71**>
90	43-**84** (30%)	37-**77** (30%)	<**72**>	<**72**>	<**68**>	<**68**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$350.99	-$430.37	-$417.46	-$404.25	-$395.27	-$389.50
80	-$303.57	-$422.34	-$415.58	-$403.60	-$395.10	-$389.47
90	-$276.94	-$410.78	-$413.20	-$403.06	-$394.95	-$389.43

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$231.55	-$351.59	-$360.37	-$359.90	-$359.70	-$360.06
80	-$178.50	-$339.26	-$354.55	-$356.12	-$356.63	-$357.32
90	-$126.09	-$327.25	-$351.80	-$354.91	-$355.73	-$356.60

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$90.93	-$138.90	-$205.14	-$240.22	-$263.51	-$280.53
80	$158.12	-$115.14	-$189.88	-$228.15	-$252.55	-$270.53
90	$214.56	-$100.95	-$184.49	-$224.50	-$249.87	-$267.96

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$246.20	-$36.49	-$130.30	-$182.56	-$217.21	-$242.23
80	$319.93	-$6.42	-$110.44	-$165.91	-$202.43	-$228.73
90	$378.67	$9.21	-$103.92	-$161.75	-$198.85	-$225.28

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$393.65	-$439.23	-$419.31	-$404.56	-$395.35	-$389.54
80	-$341.50	-$431.48	-$417.71	-$404.16	-$395.28	-$389.52
90	-$310.60	-$422.19	-$415.83	-$403.74	-$395.16	-$389.48

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$259.69	-$358.83	-$361.66	-$360.19	-$359.75	-$360.08
80	-$200.80	-$346.60	-$356.36	-$356.58	-$356.73	-$357.37
90	-$143.71	-$336.34	-$353.60	-$355.41	-$355.92	-$356.65

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$101.98	-$141.76	-$205.77	-$240.37	-$263.55	-$280.53
80	$180.21	-$117.19	-$190.70	-$228.26	-$252.61	-$270.55
90	$244.54	-$103.25	-$185.43	-$224.82	-$249.95	-$267.99

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for lodgepole plantations by site index and real alternative rates of return in the Eastside Cascades region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$276.12	-$37.24	-$130.70	-$182.65	-$217.23	-$242.23
80	$364.63	-$6.53	-$110.92	-$166.07	-$202.47	-$228.74
90	$431.58	$9.42	-$104.45	-$161.90	-$198.91	-$225.29

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for lodgepole plantations by soil productivity and real alternative rates of return in the Eastside Cascades region). (carbon value = $0/ton)

			1st thinning	2nd thinning	Final harvest	Total volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
70	2.50%	48-**89**[3] (30%)[4]	0	-	10.38	10.38
	5.00%	**79**	-[5]	-	7.45	7.45
	7.50%	60-**74** (30%)	0	-	5.9	5.9
	10.00%	**74**	-	-	5.89	5.89
	12.50%	**69**	-	-	4.12	4.12
	15.00%	**64**	-	-	3.01	3.01
80	2.50%	45-**88** (30%)	0	-	12.49	12.49
	5.00%	41-**78** (30%)	0	-	9.18	9.18
	7.50%	**72**	-	-	7.12	7.12
	10.00%	41-**68** (30%)	0	-	5.62	5.62
	12.50%	**64**	-	-	4.11	4.11
	15.00%	**64**	-	-	4.11	4.11
90	2.50%	68-84-**89** (20%)	0	2.13	11.73	13.86
	5.00%	68-**73** (30%)	0	-	9.46	9.46
	7.50%	61-**69** (30%)	0	-	7.57	7.57
	10.00%	56-**66** (25%)	0	-	6.38	6.38
	12.50%	**63**	-	-	5.13	5.13
	15.00%	**63**	-	-	5.13	5.13

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 18. Volume removed from the financially optimal schedules for lodgepole plantations by soil productivity and real alternative rates of return in the Eastside Cascades region. (carbon value = $10/ton)

			1st thinning	2nd thinning	Final harvest	Total volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
70	2.50%	48-**89**[3] (30%)[4]	0	-	10.38	10.38
	5.00%	**79**	-[5]	-	7.45	7.45
	7.50%	**77**	-	-	6.85	6.85
	10.00%	**74**	-	-	5.89	5.89
	12.50%	**74**	-	-	5.89	5.89
	15.00%	**69**	-	-	4.12	4.12
80	2.50%	45-**88** (30%)	0	-	12.49	12.49
	5.00%	41-**78** (30%)	0	-	9.18	9.18
	7.50%	**72**	-	-	7.12	7.12
	10.00%	**69**	-	-	5.86	5.86
	12.50%	**69**	-	-	5.86	5.86
	15.00%	**64**	-	-	4.11	4.11
90	2.50%	49-**84** (25%)	0	-	13.57	13.57
	5.00%	68-**73** (30%)	0	-	9.46	9.46
	7.50%	67-**72** (30%)	0	-	9.06	9.06
	10.00%	**68**	-	-	7.1	7.1
	12.50%	**63**	-	-	5.13	5.13
	15.00%	**63**	-	-	5.13	5.13

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for lodgepole plantations by soil productivity and real alternative rates of return in the Eastside Cascades region. (carbon value = $37/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final harvest MBF	Total volume MBF
70	2.50%	48-**89**[3] (30%)[4]	0	-	10.38	10.38
	5.00%	**79**	-[5]	-	7.45	7.45
	7.50%	**79**	-	-	7.45	7.45
	10.00%	**77**	-	-	6.85	6.85
	12.50%	**74**	-	-	5.89	5.89
	15.00%	**74**	-	-	5.89	5.89
80	2.50%	41-**84** (30%)	0	-	11.28	11.28
	5.00%	41-**82** (30%)	0	-	10.65	10.65
	7.50%	**74**	-	-	7.68	7.68
	10.00%	64-74-**79** (30%)	0	1.19	7.23	8.42
	12.50%	**71**	-	-	6.75	6.75
	15.00%	**69**	-	-	5.86	5.86
90	2.50%	43-**84** (30%)	0	-	13.53	13.53
	5.00%	37-**77** (30%)	0	-	10.69	10.69
	7.50%	**72**	-	-	8.98	8.98
	10.00%	**68**	-	-	7.1	7.1
	12.50%	**68**	-	-	7.1	7.1
	15.00%	**66**	-	-	6.28	6.28

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for lodgepole plantations by soil productivity and real alternative rates of return in the Eastside Cascades region. (carbon value = $50/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final harvest MBF	Total volume MBF
70	2.50%	48-**89**[3] (30%)[4]	0	-	10.38	10.38
	5.00%	**79**	-[5]	-	7.45	7.45
	7.50%	**79**	-	-	7.45	7.45
	10.00%	**79**	-	-	7.45	7.45
	12.50%	**77**	-	-	6.85	6.85
	15.00%	**74**	-	-	5.89	5.89
80	2.50%	41-**84** (30%)	0	-	11.28	11.28
	5.00%	41-**82** (30%)	0	-	10.65	10.65
	7.50%	**74**	-	-	7.68	7.68
	10.00%	**72**	-	-	7.12	7.12
	12.50%	**72**	-	-	7.12	7.12
	15.00%	**71**	-	-	6.75	6.75
90	2.50%	43-**84** (30%)	0	-	13.53	13.53
	5.00%	37-**77** (30%)	0	-	10.69	10.69
	7.50%	**72**	-	-	8.98	8.98
	10.00%	**72**	-	-	8.98	8.98
	12.50%	**68**	-	-	7.1	7.1
	15.00%	**66**	-	-	7.1	7.1

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for lodgepole plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	<48-**89**[2]>[3] (30%)[4]	<48-**89>** (30%)	0%	48-**89** (30%)	0%	48-**89** (30%)	0%
	80	<45-**88**> (30%)	<45-**88**> (30%)	0%	41-**84** (30%)	-5%	41-**84** (30%)	-5%
	90	<68-84-**89**> (20%)	<49-**84**> (25%)	-6%	43-**84** (30%)	-6%	43-**84** (30%)	-6%
5.00%	70	<**79**>	<**79**>	0%	<**79**>	0%	<**79**>	0%
	80	<41-**78**> (30%)	<41-**78**> (30%)	0%	<41-**82**> (30%)	5%	<41-**82**> (30%)	5%
	90	<68-**73**> (30%)	<68-**73**> (30%)	0%	<37-**77**> (30%)	5%	37-**77** (30%)	5%
7.50%	70	<60-**74**> (30%)	<**77**>	4%	<**79**>	7%	<**79**>	7%
	80	<**77**>	<**72**>	-6%	<**74**>	-4%	<**74**>	-4%
	90	<61-**69**> (30%)	<67-**72**> (30%)	4%	<**72**>	4%	<**72**>	4%
10.00%	70	<**74**>	<**74**>	0%	<**77**>	4%	<**79**>	7%
	80	<41-**68**> (30%)	<**69**>	1%	<64-**79**> (30%)	16%	<**72**>	6%
	90	<56-**66**> (25%)	<**68**>	3%	<**68**>	3%	<**72**>	9%
12.50%	70	<**69**>	<**74**>	7%	<**74**>	7%	<**77**>	12%
	80	<**64**>	<**69**>	8%	<**71**>	11%	<**72**>	13%
	90	<**63**>	<**63**>	0%	<**68**>	8%	<**68**>	8%
15.00%	70	<**64**>	<**69**>	8%	<**74**>	16%	<**74**>	16%
	80	<**64**>	<**64**>	0%	<**69**>	8%	<**71**>	11%
	90	<**63**>	<**63**>	0%	<**66**>	5%	<**68**>	8%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.
[4] Number in parentheses indicates the percentage of basal area removed during thinning

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for lodgepole plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	-393.65	-259.69		101.98		276.12	
	80	-341.50	-200.80		180.21		364.63	
	90	-310.60	-143.71		244.54		431.58	
5.00%	70	-439.23	-358.83		-141.76		-37.24	
	80	-431.48	-346.60		-117.19		-6.53	
	90	-422.19	-336.34		-103.25		9.42	
7.50%	70	-419.31	-361.66		-205.77		-130.70	
	80	-417.71	-356.36		-190.70		-110.92	
	90	-415.83	-353.60		-185.43		-104.45	
10.00%	70	-404.56	-360.19		-240.37		-182.65	
	80	-404.16	-356.58		-228.26		-166.07	
	90	-403.74	-355.41		-224.82		-161.90	
12.50%	70	-395.35	-359.75		-263.55		-217.23	
	80	-395.28	-356.73		-252.61		-202.47	
	90	-395.16	-355.92		-249.95		-198.91	
15.00%	70	-389.54	-360.08		-280.53		-242.23	
	80	-389.52	-357.37		-270.55		-228.74	
	90	-389.48	-356.65		-267.99		-225.29	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>Eastside Cascades- Lodgepole pine - Timber Only Rotations (C = $0/ton)</u>

Lodgepole pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 5). This optimal management regime will generate the maximum SEV of -$393.65 (Table 13), with a NPW of -$350.99 per acre (Table 9). This means that -$393.65 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$350.99 per acre for managing one rotation, or -$393.65 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 10.38 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 18.08 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Lodgepole pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 79 (Table 5). This optimal management regime will generate the maximum SEV of -$439.23 (Table 13), with a NPW of -$430.37 per acre (Table 9). This financially optimal rotation would

produce an estimated 7.45 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 14.49 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 60 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 5). This optimal management regime will generate the maximum SEV of -$419.31 (Table 13), with a NPW of -$417.46 per acre (Table 9). This financially optimal rotation would produce an estimated 5.90 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 14.76 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 74 (Table 5). This optimal management regime will generate the maximum SEV of -$404.56 (Table 13), with a NPW of -$404.25 per acre (Table 9). This financially optimal rotation would produce an estimated 5.89 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 13.99 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 69 (Table 5). This optimal management regime will generate the maximum SEV of -$395.35 (Table 13), with a NPW of -$395.27 per acre (Table 9). This financially optimal rotation would

produce an estimated 4.12 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 13.45 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 64 (Table 5). This optimal management regime will generate the maximum SEV of -$389.54 (Table 13), with a NPW of -$389.50 per acre (Table 9). This financially optimal rotation would produce an estimated 3.01 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 12.90 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 5). This optimal management regime will generate the maximum SEV of -$341.50 (Table 13), with a NPW of -$303.57 per acre (Table 9). This financially optimal rotation would produce an estimated 3 12.49 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 18.89 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand ages 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 78 (Table 5). This optimal management regime will generate the maximum SEV of -$431.48 (Table 13), with a NPW of -$422.34 per acre (Table 9). This financially optimal rotation would produce an estimated 9.18 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 17.65 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 72 (Table 5). This optimal management regime will generate the maximum SEV of -$417.71 (Table 13), with a NPW of -$415.58 per acre (Table 9). This financially optimal rotation would produce an estimated 7.12 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 14.25 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 5). This optimal management regime will generate the maximum SEV of -$404.16 (Table 13), with a NPW of -$403.60 per acre (Table 9). This financially optimal rotation would produce an estimated 5.62 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 15.78 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 64 (Table 5). This optimal management regime will generate the maximum SEV of -$395.28 (Table 13), with a NPW of -$395.10 per acre (Table 9). This financially optimal rotation would

produce an estimated 4.11 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 13.35 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 64 (Table 5). This optimal management regime will generate the maximum SEV of -$389.52 (Table 13), with a NPW of -$389.47 per acre (Table 9). This financially optimal rotation would produce an estimated 4.11 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 13.35 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 68 and 84 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 5). This optimal management regime will generate the maximum SEV of -$310.60 (Table 13), with a NPW of -$276.94 per acre (Table 9). This financially optimal rotation would produce an estimated 13.86 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 17.43 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 68 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 73 (Table 5). This optimal management regime will generate the maximum SEV of -$422.19 (Table 13), with a NPW of -$410.78 per acre (Table 9). This financially optimal rotation would

produce an estimated 9.46 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 15.09 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 61 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 5). This optimal management regime will generate the maximum SEV of -$415.83 (Table 13), with a NPW of -$413.20 per acre (Table 9). This financially optimal rotation would produce an estimated 7.57 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 14.80 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 56 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 5). This optimal management regime will generate the maximum SEV of -$403.74 (Table 13), with a NPW of -$403.06 per acre (Table 9). This financially optimal rotation would produce an estimated 6.38 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 14.41 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 63 (Table 5). This optimal management regime will generate the maximum SEV of -$395.16 (Table 13), with a NPW of -$394.95 per acre (Table 9). This financially optimal rotation would

produce an estimated 5.13 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 13.55 net tons of carbon per acre during one rotation (Table 1).

Lodgepole pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 63 (Table 5). This optimal management regime will generate the maximum SEV of -$389.48 (Table 13), with a NPW of -$389.43 per acre (Table 9). This financially optimal rotation would produce an estimated 5.13 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 13.55 net tons of carbon per acre during one rotation (Table 1).

Eastside Cascades- Lodgepole pine - Timber Only Rotations (C = $10/ton)

Lodgepole pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$259.69 (Table 14), with a NPW of -$231.55 per acre (Table 10). This means that -$259.69 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$231.55 per acre for managing one rotation, or -$259.69 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 10.38 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 18.08 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Lodgepole pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 79 (Table 6). This optimal management regime will generate the maximum SEV of -$358.83 (Table 14), with a NPW of -$351.59 per acre (Table 10). This financially optimal rotation would produce an estimated 7.45 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 14.49 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 77 (Table 6). This optimal management regime will generate the maximum SEV of -$361.66 (Table 14), with a NPW of -$360.37 per acre (Table 10). This financially optimal rotation would produce an estimated 6.85 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 14.30 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 74 (Table 6). This optimal management regime will generate the maximum SEV of -$360.19 (Table 14), with a NPW of -$359.90 per acre (Table 10). This financially optimal rotation would

produce an estimated 5.89 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 13.99 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 74 (Table 6). This optimal management regime will generate the maximum SEV of -$359.75 (Table 14), with a NPW of -$359.70 per acre (Table 10). This financially optimal rotation would produce an estimated 5.89 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 13.99 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 69 (Table 6). This optimal management regime will generate the maximum SEV of -$360.08 (Table 14), with a NPW of -$360.06 per acre (Table 10). This financially optimal rotation would produce an estimated 4.12 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 13.45 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 6). This optimal management regime will generate the maximum SEV of -$200.80 (Table 14), with a NPW of -$178.50 per acre (Table 10). This financially optimal rotation would

produce an estimated 12.49 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 18.89 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 78 (Table 6). This optimal management regime will generate the maximum SEV of -$346.60 (Table 14), with a NPW of -$339.26 per acre (Table 10). This financially optimal rotation would produce an estimated 9.18 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 17.65 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 72 (Table 6). This optimal management regime will generate the maximum SEV of -$356.36 (Table 14), with a NPW of -$354.55 per acre (Table 10). This financially optimal rotation would produce an estimated 7.12 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 14.25 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 69 (Table 6). This optimal management regime will generate the maximum SEV of -$356.58 (Table 14), with a NPW of -$356.12 per acre (Table 10). This financially optimal rotation would

produce an estimated 5.86 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 13.95 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 69 (Table 6). This optimal management regime will generate the maximum SEV of -$356.73 (Table 14), with a NPW of -$356.63 per acre (Table 10). This financially optimal rotation would produce an estimated 5.86 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 13.95 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 64 (Table 6). This optimal management regime will generate the maximum SEV of -$357.37 (Table 14), with a NPW of -$357.32 per acre (Table 10). This financially optimal rotation would produce an estimated 4.11 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 13.35 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 49 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 6). This optimal management regime will generate the maximum SEV of -$143.71 (Table 14), with a NPW of -$126.09 per acre (Table 10). This financially optimal rotation would

produce an estimated 13.57 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 18.43 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 68 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 73 (Table 6). This optimal management regime will generate the maximum SEV of -$336.34 (Table 14), with a NPW of -$327.25 per acre (Table 10). This financially optimal rotation would produce an estimated 9.46 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 15.09 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 67 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 72 (Table 6). This optimal management regime will generate the maximum SEV of -$353.60 (Table 14), with a NPW of -$351.80 per acre (Table 10). This financially optimal rotation would produce an estimated 9.06 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 14.99 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 68 (Table 6). This optimal management regime will generate the maximum SEV of -$355.41 (Table 14), with a NPW of -$354.91 per acre (Table 10). This financially optimal rotation would

produce an estimated 7.10 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 14.12 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 63 (Table 6). This optimal management regime will generate the maximum SEV of -$355.92 (Table 14), with a NPW of -$355.73 per acre (Table 10). This financially optimal rotation would produce an estimated 5.13 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 13.55 net tons of carbon per acre during one rotation (Table 2).

Lodgepole pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 63 (Table 6). This optimal management regime will generate the maximum SEV of -$356.65 (Table 14), with a NPW of -$356.60 per acre (Table 10). This financially optimal rotation would produce an estimated 5.13 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 13.55 net tons of carbon per acre during one rotation (Table 2).

Eastside Cascades-Lodgepole pine - Timber Only Rotations (C = $37/ton)

Lodgepole pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of $101.98 (Table 15),

with a NPW of $90.93 per acre (Table 11). This means that $101.98 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $90.93 per acre for managing one rotation, or $101.98 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 10.38 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 18.08 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Lodgepole pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 79 (Table 7). This optimal management regime will generate the maximum SEV of -$141.76 (Table 15), with a NPW of -$138.90 per acre (Table 11). This financially optimal rotation would produce an estimated 7.45 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 14.49 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 79 (Table 7). This optimal management regime will generate the maximum SEV of -$205.77 (Table 15), with a NPW of -$205.14 per acre (Table 11). This financially optimal rotation would

produce an estimated 7.45 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 14.49 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 77 (Table 7). This optimal management regime will generate the maximum SEV of -$240.37 (Table 15), with a NPW of -$240.22 per acre (Table 11). This financially optimal rotation would produce an estimated 6.85 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 14.30 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 74 (Table 7). This optimal management regime will generate the maximum SEV of -$263.55 (Table 15), with a NPW of -$263.51 per acre (Table 11). This financially optimal rotation would produce an estimated 5.89 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 13.99 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 74 (Table 7). This optimal management regime will generate the maximum SEV of -$280.53 (Table 15), with a NPW of -$280.53 per acre (Table 11). This financially optimal rotation would produce an estimated 5.89 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 13.99 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 7). This optimal management regime will generate the maximum SEV of $180.21 (Table 15), with a NPW of $158.12 per acre (Table 11). This financially optimal rotation would produce an estimated 11.28 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 18.53 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 7). This optimal management regime will generate the maximum SEV of -$117.19 (Table 15), with a NPW of -$115.14 per acre (Table 11). This financially optimal rotation would produce an estimated 10.65 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 18.43 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 74 (Table 7). This optimal management regime will generate the maximum SEV of -$190.70 (Table 15), with a NPW of -$189.88 per acre (Table 11). This financially optimal rotation would produce an estimated 7.68 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 14.51 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 64 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 7). This optimal management regime will generate the maximum SEV of -$228.26 (Table 15), with a NPW of -$228.15 per acre (Table 11). This financially optimal rotation would produce an estimated 8.42 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 15.73 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 71 (Table 7). This optimal management regime will generate the maximum SEV of -$252.61 (Table 15), with a NPW of -$252.55 per acre (Table 11). This financially optimal rotation would produce an estimated 6.75 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 14.15 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 69 (Table 7). This optimal management regime will generate the maximum SEV of -$270.55 (Table 15), with a NPW of -$270.53 per acre (Table 11). This financially optimal rotation would produce an estimated 5.86 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 13.95 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 43 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 7). This optimal management regime will generate the maximum SEV of $244.54 (Table 15), with a NPW of $214.56 per acre (Table 11). This financially optimal rotation would produce an estimated 13.53 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 18.88 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which thinning is conducted at stand age 37 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 7). This optimal management regime will generate the maximum SEV of -$103.25 (Table 15), with a NPW of -$100.95 per acre (Table 11). This financially optimal rotation would produce an estimated 10.69 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 18.16 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 72 (Table 7). This optimal management regime will generate the maximum SEV of -$185.43 (Table 15), with a NPW of -$184.49 per acre (Table 11). This financially optimal rotation would produce an estimated 8.98 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 14.60 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 68 (Table 7). This optimal management regime will generate the maximum SEV of -$224.82 (Table 15), with a NPW of -$224.50 per acre (Table 11). This financially optimal rotation would produce an estimated 7.10 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 14.12 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 68 (Table 7). This optimal management regime will generate the maximum SEV of -$249.95 (Table 15), with a NPW of -$249.87 per acre (Table 11). This financially optimal rotation would produce an estimated 7.10 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 14.12 net tons of carbon per acre during one rotation (Table 3).

Lodgepole pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 66 (Table 7). This optimal management regime will generate the maximum SEV of -$267.99 (Table 15), with a NPW of -$267.96 per acre (Table 11). This financially optimal rotation would produce an estimated 6.28 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 13.91 net tons of carbon per acre during one rotation (Table 3).

<u>Eastside Cascades- Lodgepole pine - Timber Only Rotations (C = $50/ton)</u>

Lodgepole pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of $276.12 (Table 16), with a NPW of $246.20 per acre (Table 12). This means that $276.12 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $246.20 per acre for managing one rotation, or $276.12 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 10.38 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 18.08 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Lodgepole pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 79 (Table 8). This optimal management regime will generate the maximum SEV of -$37.24 (Table 16), with a NPW of -$36.49 per acre (Table 12). This financially optimal rotation would produce

an estimated 7.45 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 14.49 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 79 (Table 8). This optimal management regime will generate the maximum SEV of -$130.70 (Table 16), with a NPW of -$130.30 per acre (Table 12). This financially optimal rotation would produce an estimated 7.45 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 14.49 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 79 (Table 8). This optimal management regime will generate the maximum SEV of -$182.65 (Table 16), with a NPW of -$182.56 per acre (Table 12). This financially optimal rotation would produce an estimated 7.45 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 14.49 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 77 (Table 8). This optimal management regime will generate the maximum SEV of -$217.23 (Table 16), with a NPW of -$217.21 per acre (Table 12). This financially optimal rotation would produce an estimated 6.85 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 14.30 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 74 (Table 8). This optimal management regime will generate the maximum SEV of -$242.23 (Table 16), with a NPW of -$242.23 per acre (Table 12). This financially optimal rotation would produce an estimated 5.89 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 13.99 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 8). This optimal management regime will generate the maximum SEV of $364.63 (Table 16), with a NPW of $319.93 per acre (Table 12). This financially optimal rotation would produce an estimated 11.28 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 18.53 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 8). This optimal management regime will generate the maximum SEV of -$6.53 (Table 16), with a NPW of -$6.42 per acre (Table 12). This financially optimal rotation would produce an estimated 10.65 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 18.43 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 74 (Table 8). This optimal management regime will generate the maximum SEV of -$110.92 (Table 16), with a NPW of -$110.44 per acre (Table 12). This financially optimal rotation would produce an estimated 7.68 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 14.51 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 72 (Table 8). This optimal management regime will generate the maximum SEV of -$166.07 (Table 16), with a NPW of -$165.91 per acre (Table 12). This financially optimal rotation would produce an estimated 7.12 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 14.25 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 72 (Table 8). This optimal management regime will generate the maximum SEV of -$202.47 (Table 16), with a NPW of -$202.43 per acre (Table 12). This financially optimal rotation would produce an estimated 7.12 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 14.25 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 71 (Table 8). This optimal management regime will generate the maximum SEV of -$228.74 (Table 16), with a NPW of -$228.73 per acre (Table 12). This financially optimal rotation would produce an estimated 6.75 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 14.15 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 43 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 8). This optimal management regime will generate the maximum SEV of $431.58 (Table 16), with a NPW of $378.67 per acre (Table 12). This financially optimal rotation would produce an estimated 13.53 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 18.88 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 37 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 8). This optimal management regime will generate the maximum SEV of $9.42 (Table 16), with a NPW of $9.21 per acre (Table 12). This financially optimal rotation would produce an estimated 10.69 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 18.16 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 72 (Table 8). This optimal management regime will generate the maximum SEV of -$104.45 (Table 16), with a NPW of -$103.92 per acre (Table 12). This financially optimal rotation would produce an estimated 8.98 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 14.60 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 72 (Table 8). This optimal management regime will generate the maximum SEV of -$161.90 (Table 16), with a NPW of -$161.75 per acre (Table 12). This financially optimal rotation would produce an estimated 8.98 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 14.60 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 68 (Table 8). This optimal management regime will generate the maximum SEV of -$198.91 (Table 16), with a NPW of -$198.85 per acre (Table 12). This financially optimal rotation would produce an estimated 7.10 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 14.12 net tons of carbon per acre during one rotation (Table 4).

Lodgepole pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 68 (Table 8). This

optimal management regime will generate the maximum SEV of -$225.29 (Table 16), with a NPW of -$225.28 per acre (Table 12). This financially optimal rotation would produce an estimated 7.10 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 14.12 net tons of carbon per acre during one rotation (Table 4).

Longleaf pine (*Pinus palustris*)

Biological Information

Longleaf pine in presettlement times grew in extensive pure stands throughout the southeastern United States, covering up to 60 million acres. By 1985 less than 4 million acres of longleaf-dominated forestland remained. The range of longleaf pine extends south from Virginia to south-central Florida then west to East Texas, and includes most of the Atlantic and Gulf Coastal Plains (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/palustris.htm. May 26, 2006) (Fig. 1).

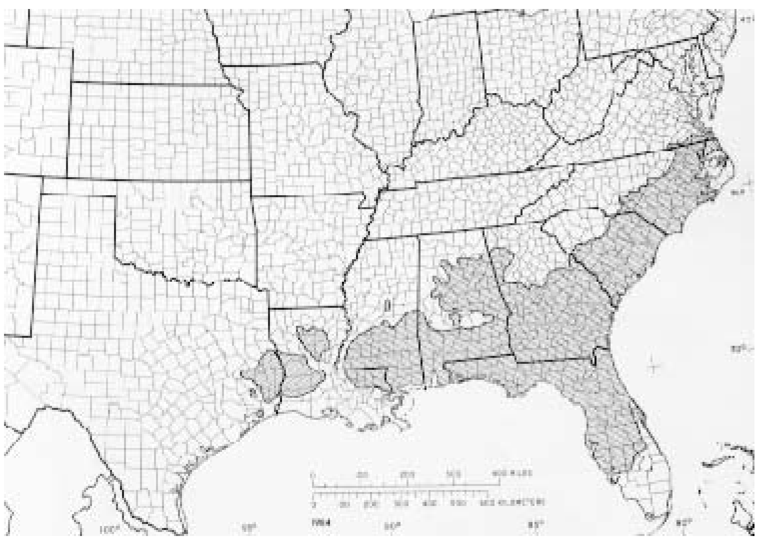

Fig. 1. The native range of longleaf pine (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/palustris.htm. May 26, 2006)

In forest conditions longleaf stems are well formed, straight, and largely free of branches. Fully stocked stands exhibit excellent self-pruning. Longleaf often produces more dry wood per unit volume than other southern yellow pines. Typically the peak in periodic annual increment culminates at around 30 years of age. Thinnings should always be conducted from below to release dominant and codominant trees (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/palustris.htm. May 26, 2006).

Longleaf pine is classified as intolerant of competition, and will grow best in the absence of all competition. Stagnation is almost never a problem in longleaf stands, but even suppressed trees will slow the growth of dominant neighbors. Dominant and codominant trees with 30 percent or greater crown ratios respond quickly in diameter growth to release. Intermediate and overtopped trees with good vigor rarely respond well to release. (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/palustris.htm. May 26, 2006).

Longleaf pine is a versatile wood and has been utilized for a variety of uses. It is suited to use as poles, pilings, posts, sawlogs, pulpwood, and naval stores. Lightered stumps are even destructively distilled to obtain chemicals. Pine straw is even baled and sold as mulching material. Regularly burned stands provide excellent habitat for game and endangered species such as the red-cockaded woodpecker (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/palustris.htm. May 26, 2006).

Economic Background

Thomson (1991) conducted a single and multiperiod to determine expected returns from investments including eight sawtimber species. To do this he had to separate the species based upon how risky of an investment they were. The relative riskiness of timber investments can be determined using the capital asset pricing model (CAPM). CAPM predicts the risk-pricing relationship where "risk is measured as the covariance of returns between an asset of interest and the market portfolio". Thompson found that in previous studies the relative riskiness of timber investments were small or even negative. Land expectation values (LEV) were calculated using the Faustmann formula, using a 5% real discount rate. It was found that risk in a portfolio was reduced sharply by adding southern pines. This addition will decrease return on a short-term investment however; in the long-run moderate risk aversion leads to increased wealth accumulation due to observed losses from riskier investments.

Stainback and Alavalapati (2004) conducted an economic analysis to assess the potential of using a silvopastural program to restore longleaf pine. Over two thirds of the longleaf pine forests in the US occur on private land. These stands provide many environmental benefits to society but landowners rarely receive compensation for them. In a silvopastural system cattle are produced along with timber, allowing landowners to diversify their income and reduce their risk exposure. Their analysis determined that a silvopasture system produced a higher land expectation value (LEV) than either traditional forestry or ranching alone. This remained constant even when carbon credits were considered ($10- $50 values). Additionally, the optimal rotation age for silvopasture was always shorter than the traditional forestry rotation age. As carbon price increased rotation lengths for both converged because the carbon payments began to play a greater role.

Roise et al. (1991) conducted an economic analysis to assess red-cockaded woodpecker habitat management and longleaf pine straw production. Pine needles offer a landowner a biennial source of income, with yields of up to 80 bales per acre per year and returns up to $160 per acre per year. The evaluations were to look at returns from stands under shelterwood management with rotations lengthened to accommodate woodpecker habitat. The results showed that pine straw contributes considerably more to land value than timber. The two together result in an even higher land value. The slope however, of both total and timber soil expectation values (SEV) are negative indicating that the optimal economic rotation occurs before age 60. Final harvest at age 60 was the shortest rotation considered due to red-cockaded woodpecker management. The SEV for pine straw alone continued to rise to the longest rotation considered (120 years), thus the optimal rotation length is greater than 120 years.

Greenhalgh and Smith (1979) conducted an economic analysis of shelterwood cutting in longleaf pine. The authors examined both shelterwood and clearcutting methods. Costs for the Shelterwood system included sale prep. and administer (-$121.91), Site prep. (-$100.00), and burning (-$10.00). The clearcut system included a planting cost of $117.40. In both instances the discount rate used was 10%. Starting with identical mature stands the shelterwood system evidenced a higher internal rate of return than the clearcut system (354.0% and 173.0% respectively). Their conclusion was that a shelterwood system would prove more favorable as long as relative costs remain constant.

Busby et al. (1993) investigated the economic potential of longleaf pine plantation investments. Their objective was to examine the potential of investing in previously thinned longleaf pine plantations. Land expectation values (LEV) were calculated for three basal area thinning strategies (60, 80, and 100 square feet per acre). Thinnings were to be conducted every five years beginning at age 16, and final harvests could range from age 16 to 46. Average costs and prices were assumed to change at the rate of inflation. Real discount rates of 3 to 7 percent were used. The optimal management strategy was to thin to a basal area of 80 sq. ft. per acre. At 5% the LEV for this strategy was $551.00 per acre compared to the 100 sq. ft. basal area LEV of $509.00 per acre, and 60 sq. ft. basal area LEV of $469.00 per acre.

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Species___Longleaf pine______________ Region______South_________________

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 7-in. inside bark top diameter for trees with a minimum of 10 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 9-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 15 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 25, 30 and 35% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.194648829 and 0.668896321, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Clark and Taras (1977) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$\mathrm{Log}_{10}Y = -0.96015+0.97497\mathrm{Log}_{10}(D^2Th)$$

where:

Y = weight of stem wood to 2-inch D.I.B. top (lbs.)

D = diameter at breast height (in.)

Th = total tree height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.6% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $296/mbf (Scribner) (Timber Mart South, Inc. 2000-2005) and pulpwood price was assumed to be $18.43/cord (Timber Mart South, Inc. 2000-2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of longleaf pine plantations in the South.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$80.28	Only once	Year 0	
Seedlings[a] (600 seedlings/ac)	$25.81	Only Once	Year 0	
Burning[a]	$21.24	Every 5 years	Year 10	Final Harvest
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al (2005).

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Table 1. Total tons of carbon sequestered per acre for longleaf pine plantations in the southern United States by site index and real alternative rates of return. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	40.44	38.91	34.30	34.30	34.30	32.34
80	45.36	39.46	42.91	40.47	40.47	40.47
90	47.15	46.54	45.16	42.66	40.16	38.19

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for longleaf pine plantations in the southern United States by site index and real alternative rates of return. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	40.44	39.47	34.30	34.30	34.30	34.30
80	45.36	43.16	42.91	40.47	40.47	40.47
90	47.25	46.54	45.16	42.66	41.73	39.95

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for longleaf pine plantations in the southern United States by site index and real alternative rates of return. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	40.44	39.80	38.91	38.33	37.26	37.26
80	45.36	44.43	42.91	41.28	40.47	40.47
90	49.72	49.24	48.05	48.23	47.01	43.80

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for longleaf pine plantations in the southern United States by site index and real alternative rates of return. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	40.44	39.80	38.91	38.91	38.33	37.26
80	45.36	44.43	42.91	42.91	41.28	40.47
90	49.72	49.53	49.09	48.52	48.52	43.80

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for longleaf pine plantations by site index and real alternative rates of return in southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	**80**[2]	**<71>**[3]	<37-43-**60**> (30%)[4]	<37-43-**60**> (30%)	<37-43-**60**> (30%)	<37-42-**59**> (35%)
80	**77**	<32-37-**60**> (35%)	**<65>**	**<59>**	**<59>**	**<59>**
90	30-35-**60** (25%)	30-36-**59** (25%)	<32-43-**56**> (25%)	<30-36-**53**> (25%)	<28-34-**51**> (35%)	<28-33-**49**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for longleaf pine plantations by site index and real alternative rates of return in southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	**80**[2]	**<74>**[3]	<37-43-**60**> (30%)[4]	<37-43-**60**> (30%)	<37-43-**60**> (30%)	<37-43-**60**> (30%)
80	**77**	**66**	**<65>**	**<59>**	**<59>**	**<59>**
90	30-36-**60** (25%)	30-36-**59** (25%)	<32-43-**56**> (25%)	<30-36-**53**> (25%)	<32-38-**51**> (25%)	<30-35-**49**> (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for longleaf pine plantations by site index and real alternative rates of return in southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	**80**[2]	**76**	**71**	**<69>**[3]	**<66>**	**<66>**
80	**77**	**72**	**65**	**61**	**<59>**	**<59>**
90	**72**	39-45-**59** (25%)[4]	38-48-**57** (25%)	40-49-**57** (25%)	<39-49-**55**> (25%)	<**54**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3] Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for longleaf pine plantations by site index and real alternative rates of return in southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	**80**[2]	**76**	**71**	**<71>**[3]	**<69>**	**<66>**
80	**77**	**72**	**65**	**65**	**<61>**	**<59>**
90	**72**	41-46-**59** (25%)[4]	41-49-**58** (25%)	42-51-**57** (25%)	42-51-**57** (25%)	<**54**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3] Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for longleaf pine plantations by site index and real alternative rates of return in southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$787.58	-$179.70	-$285.92	-$305.14	-$305.37	-$302.26
80	$1,255.76	-$27.90	-$239.90	-$280.43	-$289.66	-$291.35
90	$1,414.13	$92.30	-$210.38	-$279.34	-$295.42	-$297.96

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for longleaf pine plantations by site index and real alternative rates of return in southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,053.09	-$30.66	-$201.60	-$247.57	-$264.04	-$271.31
80	$1,571.24	$150.87	-$122.80	-$201.49	-$232.77	-$248.46
90	$1,724.86	$292.30	-$74.75	-$184.40	-$225.15	-$243.78

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for longleaf pine plantations by site index and real alternative rates of return in southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,769.96	$376.96	$38.64	-$88.55	-$150.94	-$186.96
80	$2,423.02	$654.74	$193.37	$11.89	-$79.16	-$132.67
90	$2,779.93	$847.42	$300.48	$79.46	-$30.47	-$94.14

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for longleaf pine plantations by site index and real alternative rates of return in southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$2,115.12	$573.34	$157.74	-$10.04	-$95.80	-$146.10
80	$2,833.14	$898.10	$345.60	$115.13	-$5.17	-$76.91
90	$3,250.08	$1,121.60	$484.09	$208.33	$64.42	-$21.38

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for longleaf pine plantations by site index and real alternative rates of return in southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$910.84	-$185.22	-$289.43	-$306.06	-$305.60	-$302.33
80	$1,469.98	-$29.40	-$241.95	-$281.35	-$289.91	-$291.41
90	$1,817.04	$97.52	-$213.84	-$280.97	-$296.07	-$298.23

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for longleaf pine plantations by site index and real alternative rates of return in southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,217.90	-$31.47	-$204.08	-$248.31	-$264.24	-$271.37
80	$1,839.27	$156.84	-$123.85	-$202.16	-$232.97	-$248.52
90	$2,216.30	$308.84	-$75.98	-$185.48	-$225.64	-$244.00

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for longleaf pine plantations by site index and real alternative rates of return in southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$2,046.95	$385.97	$38.85	-$88.66	-$151.00	-$186.98
80	$2,836.36	$673.87	$195.02	$11.93	-$79.23	-$132.70
90	$3,328.76	$895.36	$305.08	$79.78	-$30.51	-$94.18

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for longleaf pine plantations by site index and real alternative rates of return in southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$2,446.13	$587.06	$158.61	-$10.05	-$95.82	-$146.11
80	$3,316.44	$924.35	$348.55	$115.35	-$5.17	-$76.93
90	$3,891.74	$1,185.04	$490.97	$209.16	$64.49	-$21.39

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for longleaf pine plantations by soil productivity and real alternative rates of return in southern United States. (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	**80**[3]	-[5]	-	-	-	1,545.68	20.57	1,545.68	20.57
	5.00%	**<71>**	-	-	-	-	2,460.84	14.24	2,460.84	14.24
	7.50%	<37-43-**60**> (30%)[4]	578.68	0	698.58	0	1,581.24	7.65	2,858.50	7.65
	10.00%	<37-43-**60**> (30%)	578.68	0	698.58	0	1,581.24	7.65	2,858.50	7.65
	12.50%	<37-43-**60**> (30%)	578.68	0	698.58	0	1,581.24	7.65	2,858.50	7.65
	15.00%	<37-42-**59**> (35%)	696.15	0	734.08	0	1,237.07	7.13	2,667.30	7.13
80	2.50%	**77**	-	-	-	-	1,282.14	24.64	1,282.14	24.64
	5.00%	<32-37-**60**> (35%)	635.40	0	774.71	0	554.67	14.85	1964.78	14.85
	7.50%	**<65>**	-	-	-	-	2,570.60	15.73	2,570.60	15.73
	10.00%	**<59>**	-	-	-	-	3,359.41	9.98	3,359.41	9.98
	12.50%	**<59>**	-	-	-	-	3,359.41	9.98	3,359.41	9.98
	15.00%	**<59>**	-	-	-	-	3,359.41	9.98	3,359.41	9.98
90	2.50%	30-35-**60** (25%)	578.96	0	691.43	0	670.59	20.34	1,940.98	20.34
	5.00%	30-36-**59** (25%)	578.96	0	725.42	0	676.48	19.72	1,980.86	19.72
	7.50%	<32-43-**56**> (25%)	721.48	0	931.33	0	799.23	16.72	2,452.04	16.72
	10.00%	<30-36-**53**> (25%)	578.96	0	725.42	0	1,436.10	13.22	2,740.48	13.22
	12.50%	<28-34-**51**> (35%)	613.46	0	870.44	0	978.81	12.05	2,462.71	12.05
	15.00%	<28-33-**49**> (35%)	613.46	0	819.46	0	1,399.12	9.00	2,832.04	9.00

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 18. Volume removed from the financially optimal schedules for longleaf pine plantations by soil productivity and real alternative rates of return in southern United States. (carbon value = $10/ton)

Site Index[1]	ARR	Schedule	1st thinning		2nd thinning		Final Harvest		Total Volume	
			Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	**80**[3]	-[5]	-	-	-	1,545.68	20.57	1,545.68	20.57
	5.00%	**<71>**	-	-	-	-	2,167.98	16.30	2,167.98	16.30
	7.50%	<37-43-**60**> (30%)[4]	578.68	0	698.58	0	1,581.24	7.65	2,858.50	7.65
	10.00%	<37-43-**60**> (30%)	578.68	0	698.58	0	1,581.24	7.65	2,858.50	7.65
	12.50%	<37-43-**60**> (30%)	578.68	0	698.58	0	1,581.24	7.65	2,858.50	7.65
	15.00%	<37-43-**60**> (30%)	578.68	0	698.58	0	1,581.24	7.65	2,858.50	7.65
80	2.50%	**77**	-	-	-	-	1,282.14	24.64	1,282.14	24.64
	5.00%	**66**	-	-	-	-	2,454.44	16.50	2,454.44	16.50
	7.50%	**<65>**	-	-	-	-	2,570.60	15.73	2,570.60	15.73
	10.00%	**<59>**	-	-	-	-	3,359.41	9.98	3,359.41	9.98
	12.50%	**<59>**	-	-	-	-	3,359.41	9.98	3,359.41	9.98
	15.00%	**<59>**	-	--	-	-	3,359.41	9.98	3,359.41	9.98
90	2.50%	30-36-**60** (25%)	578.96	0	725.42	0	664.99	20.33	1,969.37	20.33
	5.00%	30-36-**59** (25%)	578.96	0	725.42	0	676.48	19.72	1,980.86	19.72
	7.50%	<32-43-**56**> (25%)	721.48	0	931.33	0	799.23	16.72	2,452.04	16.72
	10.00%	<30-36-**53**> (25%)	578.96	0	725.42	0	1,436.10	13.22	2,740.48	13.22
	12.50%	<32-38-**51**> (25%)	721.48	0	777.67	0	1,745.02	10.55	3,244.17	10.55
	15.00%	<30-35-**49**> (25%)	578.96	0	691.43	0	2,145.54	8.13	3,415.93	8.13

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for longleaf pine plantations by soil productivity and real alternative rates of return in southern United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	**80**[3]	-[5]	-	-	-	1,545.68	20.57	1,545.68	20.57
	5.00%	**76**	-	-	-	-	1,923.34	17.87	1,923.34	17.87
	7.50%	**71**	-	-	-	-	2,460.84	14.24	2,460.84	14.24
	10.00%	**<69>**	-	-	-	-	2,763.21	12.19	2,763.21	12.19
	12.50%	**<66>**	-	-	-	-	3,151.88	9.42	3,151.88	9.42
	15.00%	**<66>**	-	-	-	-	3,151.88	9.42	3,151.88	9.42
80	2.50%	**77**	-	-	-	-	1,282.14	24.64	1,282.14	24.64
	5.00%	**72**	-	-	-	-	1,713.73	21.42	1,713.73	21.42
	7.50%	**65**	-	-	-	-	2,570.60	15.73	2,570.60	15.73
	10.00%	**61**	-	-	-	-	3,117.87	11.79	3,117.87	11.79
	12.50%	**<59>**	-	-	-	-	3,359.41	9.98	3,359.41	9.98
	15.00%	**<59>**	-	-	-	-	3,359.41	9.98	3,359.41	9.98
90	2.50%	**72**	-	-	-	-	1,215.51	27.02	1,215.51	27.02
	5.00%	39-45-**59** (25%)[4]	1,014.67	0	998.44	0	650.97	18.65	2,664.08	18.65
	7.50%	38-48-**57** (25%)	972.43	0	1,092.94	0	740.09	17.01	2,805.46	17.01
	10.00%	40-49-**57** (25%)	1,054.30	0	1,109.91	0	726.76	16.68	2,890.97	16.68
	12.50%	<39-49-**55**> (25%)	1,014.67	0	1,118.22	0	1,136.52	14.08	3,269.41	14.08
	15.00%	<**54**>	-	-	-	-	3,491.53	11.13	3,491.53	11.13

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]**Indicates no operation conducted.**

Table 20. Volume removed from the financially optimal schedules for longleaf pine plantations by soil productivity and real alternative rates of return in southern United States. (carbon value = $50/ton)

Site Index[1]	ARR	Schedule	1st thinning Cu. Ft.	1st thinning MBF[2]	2nd thinning Cu. Ft.	2nd thinning MBF	Final Harvest Cu. Ft.	Final Harvest MBF	Total Volume Cu. Ft.	Total Volume MBF
70	2.50%	**80**[3]	-[5]	-	-	-	1,545.68	20.57	1,545.68	20.57
	5.00%	**76**	-	-	-	-	1,923.34	17.87	1,923.34	17.87
	7.50%	**71**	-	-	-	-	2,460.84	14.24	2,460.84	14.24
	10.00%	**<71>**	-	-	-	-	2,460.84	14.24	2,460.84	14.24
	12.50%	**<69>**	-	-	-	-	2,763.21	12.19	2,763.21	12.19
	15.00%	**<66>**	-	-	-	-	3,151.88	9.42	3,151.88	9.42
80	2.50%	**77**	-	-	-	-	1,282.14	24.64	1,282.14	24.64
	5.00%	**72**	-	-	-	-	1,713.73	21.42	1,713.73	21.42
	7.50%	**65**	-	-	-	-	2,570.60	15.73	2,570.60	15.73
	10.00%	**65**	-	-	-	-	2,570.60	15.73	2,570.60	15.73
	12.50%	**<61>**	-	-	-	-	3,117.87	11.79	3,117.87	11.79
	15.00%	**<59>**	-	-	-	-	3,359.41	9.98	3,359.41	9.98
90	2.50%	**72**	-	-	-	-	1,215.51	27.02	1,215.51	27.02
	5.00%	41-46-**59** (25%)[4]	1096.38	0	1017.18	0	646.88	18.43	2,760.44	18.43
	7.50%	41-49-**58** (25%)	1096.38	0	1106.17	0	673.54	17.48	2,876.09	17.48
	10.00%	42-51-**57** (25%)	1123.81	0	1150.69	0	805.85	16.12	3,080.35	16.12
	12.50%	42-51-**57** (25%)	1123.81	0	1150.69	0	805.85	16.12	3,080.35	16.12
	15.0%	<**54**>	-	-	-	-	3,491.53	11.13	3,491.53	11.13

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]**Indicates no operation conducted.**

Table 21. Financially optimal thinning and final harvest schedules for longleaf pine plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	**80**[2]	**80**	0%	**80**	0%	**80**	0%
	80	**77**	**77**	0%	**77**	0%	**77**	0%
	90	30-35-**60** (25%)[3]	30-36-**60** (25%)	0%	**72**	20%	**72**	20%
5.00%	70	**<71>**[4]	**<74>**	4%	**76**	7%	**76**	7%
	80	<32-37-**60**> (35%)	**66**	10%	**72**	20%	**72**	20%
	90	30-36-**59** (25%)	30-36-**59** (25%)	0%	39-45-**59** (25%)	0%	41-46-**59** (25%)	0%
7.50%	70	<37-43-**60**> (30%)	<37-43-**60**> (30%)	0%	**71**	18%	**71**	18%
	80	**<65>**	**<65>**	0%	**65**	0%	**65**	0%
	90	<32-43-**56**> (25%)	<32-43-**56**> (25%)	0%	38-48-**57** (25%)	2%	41-49-**58** (25%)	4%
10.00%	70	<37-43-**60**> (30%)	<37-43-**60**> (30%)	0%	**<69>**	15%	**<71>**	18%
	80	**<59>**	**<59>**	0%	**61**	3%	**65**	10%
	90	<30-36-**53**> (25%)	<30-36-**53**> (25%)	0%	40-49-**57** (25%)	8%	42-51-**57** (25%)	8%
12.50%	70	<37-43-**60**> (30%)	<37-43-**60**> (30%)	0%	**<66>**	10%	**<69>**	15%
	80	**<59>**	**<59>**	0%	**<59>**	0%	**<61>**	3%
	90	<28-34-**51**> (35%)	<32-38-**51**> (25%)	0%	<39-49-**55**> (25%)	8%	42-51-**57** (25%)	12%
15.00%	70	<37-42-**59**> (35%)	<37-43-**60**> (30%)	2%	**<66>**	12%	**<66>**	12%
	80	**<59>**	**<59>**	0%	**<59>**	0%	**<59>**	0%
	90	<28-33-**49**> (35%)	<30-35-**49**> (25%)	0%	<**54**>	10%	<**54**>	10%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning
[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for longleaf pine plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	910.84	1,217.90	34%	2,046.95	68%	2,446.13	169%
	80	1,469.98	1,839.27	25%	2,836.36	54%	3,316.44	126%
	90	1,817.04	2,216.30	22%	3,328.76	50%	3,891.74	114%
5.00%	70	-185.22	-31.47		385.97		587.06	
	80	-29.40	156.84		673.87		924.35	
	90	97.52	308.84		895.36		1,185.04	
7.50%	70	-289.43	-204.08		38.85		158.61	
	80	-241.95	-123.85		195.02		348.55	
	90	-213.84	-75.98		305.08		490.97	
10.00%	70	-306.06	-248.31		-88.66		-10.05	
	80	-281.35	-202.16		11.93		115.35	
	90	-280.97	-185.48		79.78		209.16	
12.50%	70	-305.60	-264.24		-151.00		-95.82	
	80	-289.91	-232.97		-79.23		-5.17	
	90	-296.07	-225.64		-30.51		64.49	
15.00%	70	-302.33	-271.37		-186.98		-146.11	
	80	-291.41	-248.52		-132.70		-76.93	
	90	-298.23	-244.00		-94.18		-21.39	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

Southern- Longleaf Pine - Timber Only Rotations (C = $0/ton)

Longleaf Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest at stand age 80 is conducted (Table 5). This optimal management regime will generate the maximum SEV of $910.84 (Table 13), with a NPW of $787.58 per acre (Table 9). This means that $910.84 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $787.58 per acre for managing one rotation, or $910.84 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 1,545.68 cubic feet of pulpwood and 20.57 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 40.44 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Longleaf Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest at stand age 71 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$185.22 (Table 13), with a NPW of -$179.70 per acre (Table 9). This financially optimal rotation could produce an estimated 2,460.84 cubic feet of pulpwood and 14.24 MBF of sawlogs per

acre from the thinning and final harvest (Table 17), and sequester 38.91 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 37 and 43 (with 30 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$289.43 (Table 13), with a NPW of -$285.92 per acre (Table 9). This financially optimal rotation could produce an estimated 2,858.50 cubic feet of pulpwood and 7.65 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 34.30 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 37 and 43 (with 30 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$306.06 (Table 13), with a NPW of -$305.14 per acre (Table 9). This financially optimal rotation could produce an estimated 2,858.50 cubic feet of pulpwood and 7.65 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 34.30 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 37 and 43 (with 30 percent of

basal area removed) and a final harvest at stand age 60 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$305.60 (Table 13), with a NPW of -$305.37 per acre (Table 9). This financially optimal rotation could produce an estimated 2,858.50 cubic feet of pulpwood and 7.65 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 34.30 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 37 and 42 (with 35 percent of basal area removed) and a final harvest at stand age 59 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$302.33 (Table 13), with a NPW of -$302.26 per acre (Table 9). This financially optimal rotation could produce an estimated 2,667.30 cubic feet of pulpwood and 7.13 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 32.34 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest at stand age 77 is conducted (Table 5). This optimal management regime will generate the maximum SEV of $1,469.98 (Table 13), with a NPW of $1,255.76 per acre (Table 9). This financially optimal rotation could produce an estimated 1,282.14 cubic feet of pulpwood and 24.64 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 45.36 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 32 and 37 (with 35 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$29.40 (Table 13), with a NPW of -$27.90 per acre (Table 9). This financially optimal rotation could produce an estimated 1,964.78 cubic feet of pulpwood and 14.85 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 39.46 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest at stand age 65 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$241.95 (Table 13), with a NPW of -$239.90 per acre (Table 9). This financially optimal rotation could produce an estimated 2,570.60 cubic feet of pulpwood and 15.73 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 42.91 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest at stand age 59 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$281.35 (Table 13), with a NPW of -$280.43 per acre (Table 9). This financially optimal rotation could produce an estimated 3,359.41 cubic feet of pulpwood and 9.98 MBF of sawlogs per acre

from the thinning and final harvest (Table 17), and sequester 40.47 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest at stand age 59 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$289.91 (Table 13), with a NPW of -$289.66 per acre (Table 9). This financially optimal rotation could produce an estimated 3,359.41 cubic feet of pulpwood and 9.98 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 40.47 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest at stand age 59 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$291.41 (Table 13), with a NPW of -$291.35 per acre (Table 9). This financially optimal rotation could produce an estimated 3,359.41 cubic feet of pulpwood and 9.98 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 40.47 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with 25 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 5). This optimal management regime will generate the maximum SEV of $1,817.04 (Table 13),

with a NPW of $1,414.13 per acre (Table 9). This financially optimal rotation could produce an estimated 1,940.98 cubic feet of pulpwood and 20.34 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 47.15 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 30 and 36 (with 25 percent of basal area removed) and a final harvest at stand age 59 is conducted (Table 5). This optimal management regime will generate the maximum SEV of $97.52 (Table 13), with a NPW of $92.30 per acre (Table 9). This financially optimal rotation could produce an estimated 1,980.86 cubic feet of pulpwood and 19.72 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 46.54 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 32 and 43 (with 25 percent of basal area removed) and a final harvest at stand age 56 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$213.84 (Table 13), with a NPW of -$210.38 per acre (Table 9). This financially optimal rotation could produce an estimated 2,452.04 cubic feet of pulpwood and 16.72 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 45.16 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 30 and 36 (with 25 percent of basal area removed) and a final harvest at stand age 53 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$280.97 (Table 13), with a NPW of -$279.34 per acre (Table 9). This financially optimal rotation could produce an estimated 2,740.48 cubic feet of pulpwood and 13.22 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 42.66 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 28 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 51 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$296.07 (Table 13), with a NPW of -$295.42 per acre (Table 9). This financially optimal rotation could produce an estimated 2,462.71 cubic feet of pulpwood and 12.05 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 40.16 net tons of carbon per acre during one rotation (Table 1).

Longleaf Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 28 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 49 is conducted (Table 5). This optimal management regime will generate the maximum SEV of -$298.23 (Table 13), with a NPW of -$297.96 per acre (Table 9). This financially optimal rotation could

produce an estimated 2,832.04 cubic feet of pulpwood and 9.00 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 38.19 net tons of carbon per acre during one rotation (Table 1).

Southern- Longleaf Pine - Timber Only Rotations (C = $10/ton)

Longleaf Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest at stand age 80 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $1,217.90 (Table 14), with a NPW of $1,053.09 per acre (Table 10). This means that $1,217.90 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,053.09 per acre for managing one rotation, or $1,217.90 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 1,545.68 cubic feet of pulpwood and 20.57 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.44 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Longleaf Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest at stand age 74 is conducted (Table 6). This

optimal management regime will generate the maximum SEV of -$31.47 (Table 14), with a NPW of -$30.66 per acre (Table 10). This financially optimal rotation could produce an estimated 2,167.98 cubic feet of pulpwood and 16.30 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 39.47 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 37 and 43 (with 30 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$204.08 (Table 14), with a NPW of -$201.60 per acre (Table 10). This financially optimal rotation could produce an estimated 2,858.50 cubic feet of pulpwood and 7.65 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 34.30 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 37 and 43 (with 30 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$248.31 (Table 14), with a NPW of -$247.57 per acre (Table 10). This financially optimal rotation could produce an estimated 2,858.50 cubic feet of pulpwood and 7.65 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 34.30 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 37 and 43 (with 30 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$264.24 (Table 14), with a NPW of -$264.04 per acre (Table 10). This financially optimal rotation could produce an estimated 2,858.50 cubic feet of pulpwood and 7.65 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 34.30 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 37 and 43 (with 30 percent of basal area removed) and a final harvest at stand age 60 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$271.37 (Table 14), with a NPW of -$271.31 per acre (Table 10). This financially optimal rotation could produce an estimated 2,858.50 cubic feet of pulpwood and 7.65 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 34.30 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest at stand age 77 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $1,839.27 (Table 14), with a NPW of $1,571.24 per acre (Table 10). This financially optimal rotation could

produce an estimated 1,282.14 cubic feet of pulpwood and 24.64 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 45.36 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest at stand age 66 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $156.84 (Table 14), with a NPW of $150.87 per acre (Table 10). This financially optimal rotation could produce an estimated 2,454.44 cubic feet of pulpwood and 16.50 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 43.16 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest at stand age 65 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$123.85 (Table 14), with a NPW of -$122.80 per acre (Table 10). This financially optimal rotation could produce an estimated 2,570.60 cubic feet of pulpwood and 15.73 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 42.91 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest at stand age 59 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$202.16 (Table 14), with a NPW of -$201.49 per acre (Table 10). This financially optimal rotation could produce an estimated 3,359.41 cubic feet of pulpwood and 9.98 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.47 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest at stand age 59 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$232.97 (Table 14), with a NPW of -$232.77 per acre (Table 10). This financially optimal rotation could produce an estimated 3,359.41 cubic feet of pulpwood and 9.98 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.47 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest at stand age 59 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$248.52 (Table 14), with a NPW of -$248.46 per acre (Table 10). This financially optimal rotation could produce an estimated 3,359.41 cubic feet of pulpwood and 9.98 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.47 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 30 and 36 (with 25 percent of

basal area removed) and a final harvest at stand age 60 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $2,216.30 (Table 14), with a NPW of $1,724.86 per acre (Table 10). This financially optimal rotation could produce an estimated 1,969.37 cubic feet of pulpwood and 20.33 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 47.25 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 30 and 36 (with 25 percent of basal area removed) and a final harvest at stand age 59 is conducted (Table 6). This optimal management regime will generate the maximum SEV of $308.84 (Table 14), with a NPW of $292.30 per acre (Table 10). This financially optimal rotation could produce an estimated 1,980.86 cubic feet of pulpwood and 19.72 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 46.54 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 32 and 43 (with 25 percent of basal area removed) and a final harvest at stand age 56 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$75.98 (Table 14), with a NPW of -$74.75 per acre (Table 10). This financially optimal rotation could produce an estimated 2,452.04 cubic feet of pulpwood and 16.72 MBF of sawlogs per acre from the

thinning and final harvest (Table 18), and sequester 45.16 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 30 and 36 (with 25 percent of basal area removed) and a final harvest at stand age 53 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$185.48 (Table 14), with a NPW of -$184.40 per acre (Table 10). This financially optimal rotation could produce an estimated 2,740.48 cubic feet of pulpwood and 13.22 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 42.66 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 32 and 38 (with 25 percent of basal area removed) and a final harvest at stand age 51 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$225.64 (Table 14), with a NPW of -$225.15 per acre (Table 10). This financially optimal rotation could produce an estimated 3,244.17 cubic feet of pulpwood and 10.55 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 41.73 net tons of carbon per acre during one rotation (Table 2).

Longleaf Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with 25 percent of

basal area removed) and a final harvest at stand age 49 is conducted (Table 6). This optimal management regime will generate the maximum SEV of -$244.00 (Table 14), with a NPW of -$243.78 per acre (Table 10). This financially optimal rotation could produce an estimated 3,415.93 cubic feet of pulpwood and 8.13 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 39.95 net tons of carbon per acre during one rotation (Table 2).

Southern- Longleaf Pine - Timber Only Rotations (C = $37/ton)

Longleaf Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest at stand age 80 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $2,046.95 (Table 15), with a NPW of $1,769.96 per acre (Table 11). This means that $2,046.95 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,769.96 per acre for managing one rotation, or $2,046.95 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 1,545.68 cubic feet of pulpwood and 20.57 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.44 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Longleaf Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest at stand age 76 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $385.97 (Table 15), with a NPW of $376.96 per acre (Table 11). This financially optimal rotation could produce an estimated 1,923.34 cubic feet of pulpwood and 17.87 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 39.80 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest at stand age 71 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $38.85 (Table 15), with a NPW of $38.64 per acre (Table 11). This financially optimal rotation could produce an estimated 2,460.84 cubic feet of pulpwood and 14.24 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 38.91 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest at stand age 69 is conducted (Table 7). This optimal management regime will generate the maximum SEV of -$88.66 (Table 15), with a NPW of -$88.55 per acre (Table 11). This financially optimal rotation could produce an estimated 2,763.21 cubic feet of pulpwood and 12.19 MBF of sawlogs per acre from

the thinning and final harvest (Table 19), and sequester 38.33 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest at stand age 66 is conducted (Table 7). This optimal management regime will generate the maximum SEV of -$151.00 (Table 15), with a NPW of -$150.94 per acre (Table 11). This financially optimal rotation could produce an estimated 3,151.88 cubic feet of pulpwood and9.42 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 37.26 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest at stand age 66 is conducted (Table 7). This optimal management regime will generate the maximum SEV of -$186.98 (Table 15), with a NPW of -$186.96 per acre (Table 11). This financially optimal rotation could produce an estimated 3,151.88 cubic feet of pulpwood and9.42 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 37.26 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest at stand age 77 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $2,836.36 (Table 15), with a NPW of $2,423.02 per acre (Table 11). This financially optimal rotation could

produce an estimated 1,282.14 cubic feet of pulpwood and 24.64 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 45.36 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest at stand age 72 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $673.87 (Table 15), with a NPW of $654.74 per acre (Table 11). This financially optimal rotation could produce an estimated 1,713.73 cubic feet of pulpwood and 21.42 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 44.43 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest at stand age 65 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $195.02 (Table 15), with a NPW of $193.37 per acre (Table 11). This financially optimal rotation could produce an estimated 2,570.60 cubic feet of pulpwood and 15.73 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 42.91 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest at stand age 61 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $11.93 (Table 15), with a NPW of $11.89 per acre (Table 11). This financially optimal rotation could produce an estimated 3,117.87 cubic feet of pulpwood and 11.79 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 41.28 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest at stand age 59 is conducted (Table 7). This optimal management regime will generate the maximum SEV of -$79.23 (Table 15), with a NPW of -$79.16 per acre (Table 11). This financially optimal rotation could produce an estimated 3,359.41 cubic feet of pulpwood and 9.98 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.47 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest at stand age 59 is conducted (Table 7). This optimal management regime will generate the maximum SEV of -$132.70 (Table 15), with a NPW of -$132.67 per acre (Table 11). This financially optimal rotation could produce an estimated 3,359.41 cubic feet of pulpwood and 9.98 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.47 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest at stand age 72 is conducted (Table 7). This

optimal management regime will generate the maximum SEV of $3,328.76 (Table 15), with a NPW of $2,779.93 per acre (Table 11). This financially optimal rotation could produce an estimated 1,215.51 cubic feet of pulpwood and 27.02 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 49.72 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 39 and 45 (with 25 percent of basal area removed) and a final harvest at stand age 59 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $895.36 (Table 15), with a NPW of $847.42 per acre (Table 11). This financially optimal rotation could produce an estimated 2,664.08 cubic feet of pulpwood and 18.65 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 49.24 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 38 and 48 (with 25 percent of basal area removed) and a final harvest at stand age 57 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $305.08 (Table 15), with a NPW of $300.48 per acre (Table 11). This financially optimal rotation could produce an estimated 2,805.46 cubic feet of pulpwood and 17.01 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 48.05 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 40 and 49 (with 25 percent of basal area removed) and a final harvest at stand age 57 is conducted (Table 7). This optimal management regime will generate the maximum SEV of $79.78 (Table 15), with a NPW of $79.46 per acre (Table 11). This financially optimal rotation could produce an estimated 2,890.97 cubic feet of pulpwood and 16.68 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 48.23 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 39 and 49 (with 25 percent of basal area removed) and a final harvest at stand age 55 is conducted (Table 7). This optimal management regime will generate the maximum SEV of -$30.51 (Table 15), with a NPW of -$30.47 per acre (Table 11). This financially optimal rotation could produce an estimated 3,269.41 cubic feet of pulpwood and 14.08 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 47.01 net tons of carbon per acre during one rotation (Table 3).

Longleaf Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest at stand age 54 is conducted (Table 7). This optimal management regime will generate the maximum SEV of -$94.18 (Table 15), with a NPW of -$94.14 per acre (Table 11). This financially optimal rotation could produce

an estimated 3,491.53 cubic feet of pulpwood and 11.13 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 43.80 net tons of carbon per acre during one rotation (Table 3).

Southern- Longleaf Pine - Timber Only Rotations (C = $50/ton)

Longleaf Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest at stand age 80 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $2,446.13 (Table 16), with a NPW of $2,115.12 per acre (Table 12). This means that $2,446.13 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,115.12 per acre for managing one rotation, or $2,446.13 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 1,545.68 cubic feet of pulpwood and 20.57 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.44 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Longleaf Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest at stand age 76 is conducted (Table 8). This

optimal management regime will generate the maximum SEV of $587.06 (Table 16), with a NPW of $573.34 per acre (Table 12). This financially optimal rotation could produce an estimated 1,923.34 cubic feet of pulpwood and 17.87 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 39.80 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest at stand age 71 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $158.61 (Table 16), with a NPW of $157.74 per acre (Table 12). This financially optimal rotation could produce an estimated 2,460.84 cubic feet of pulpwood and 14.24 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 38.91 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest at stand age 71 is conducted (Table 8). This optimal management regime will generate the maximum SEV of -$10.05 (Table 16), with a NPW of -$10.04 per acre (Table 12). This financially optimal rotation could produce an estimated 2,460.84 cubic feet of pulpwood and 14.24 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 38.91 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest at stand age 69 is conducted (Table 8). This optimal management regime will generate the maximum SEV of -$95.82 (Table 16), with a NPW of -$95.80 per acre (Table 12). This financially optimal rotation could produce an estimated 2,763.21 cubic feet of pulpwood and 12.19 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 38.33 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest at stand age 66 is conducted (Table 8). This optimal management regime will generate the maximum SEV of -$146.11 (Table 16), with a NPW of -$146.10 per acre (Table 12). This financially optimal rotation could produce an estimated 3,151.88 cubic feet of pulpwood and 9.42 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 37.26 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest at stand age 77 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $3,316.44 (Table 16), with a NPW of $2,833.14 per acre (Table 12). This financially optimal rotation could produce an estimated 1,282.14 cubic feet of pulpwood and 24.64 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 45.36 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest at stand age 72 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $924.35 (Table 16), with a NPW of $898.10 per acre (Table 12). This financially optimal rotation could produce an estimated 1,713.73 cubic feet of pulpwood and 21.24 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 44.43 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest at stand age 65 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $348.55 (Table 16), with a NPW of $345.60 per acre (Table 12). This financially optimal rotation could produce an estimated 2,570.60 cubic feet of pulpwood and 15.73 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 42.91 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest at stand age 65 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $115.35 (Table 16), with a NPW of $115.13 per acre (Table 12). This financially optimal rotation could produce an estimated 2,570.60 cubic feet of pulpwood and 15.73 MBF of sawlogs per

acre from the thinning and final harvest (Table 20), and sequester 42.91 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest at stand age 61 is conducted (Table 8). This optimal management regime will generate the maximum SEV of -$5.17 (Table 16), with a NPW of -$5.17 per acre (Table 12). This financially optimal rotation could produce an estimated 3,117.87 cubic feet of pulpwood and 11.79 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 41.28 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest at stand age 59 is conducted (Table 8). This optimal management regime will generate the maximum SEV of -$76.93 (Table 16), with a NPW of -$76.91 per acre (Table 12). This financially optimal rotation could produce an estimated 3,359.41 cubic feet of pulpwood and 9.98 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 40.47 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest at stand age 72 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $3,891.74 (Table 16), with a NPW of $3,250.08 per acre (Table 12). This financially optimal rotation could

produce an estimated 1,215.51 cubic feet of pulpwood and 27.02 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 49.72 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 41 and 46 (with 25 percent of basal area removed) and a final harvest at stand age 59 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $1,185.04 (Table 16), with a NPW of $1,121.60 per acre (Table 12). This financially optimal rotation could produce an estimated 2,760.44 cubic feet of pulpwood and 18.43 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 49.53 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 41 and 49 (with 25 percent of basal area removed) and a final harvest at stand age 58 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $490.97 (Table 16), with a NPW of $484.09 per acre (Table 12). This financially optimal rotation could produce an estimated 2,876.09 cubic feet of pulpwood and 17.48 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 49.09 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 42 and 51 (with 25 percent of basal area removed) and a final harvest at stand age 57 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $209.16 (Table 16), with a NPW of $208.33 per acre (Table 12). This financially optimal rotation could produce an estimated 3,080.35 cubic feet of pulpwood and 16.12 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 48.52 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 42 and 51 (with 25 percent of basal area removed) and a final harvest at stand age 57 is conducted (Table 8). This optimal management regime will generate the maximum SEV of $64.49 (Table 16), with a NPW of $64.42 per acre (Table 12). This financially optimal rotation could produce an estimated 3,080.35 cubic feet of pulpwood and 16.12 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 48.52 net tons of carbon per acre during one rotation (Table 4).

Longleaf Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest at stand age 54 is conducted (Table 8). This optimal management regime will generate the maximum SEV of -$21.39 (Table 16), with a NPW of -$21.38 per acre (Table 12). This financially optimal rotation could produce an estimated 3,491.53 cubic feet of pulpwood and 11.13 MBF of sawlogs per acre from

the thinning and final harvest (Table 20), and sequester 43.80 net tons of carbon per acre during one rotation (Table 4).

Northern red oak (*Quercus rubra*)

Biological Information

Northern red oak is one of the more important lumber species of red oak. The native range extends from Nova Scotia west to Minnesota, south to eastern Nebraska and Oklahoma, east to southern Alabama and northern Georgia (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/quercus/rubra.htm. June 27, 2006) (Fig. 1).

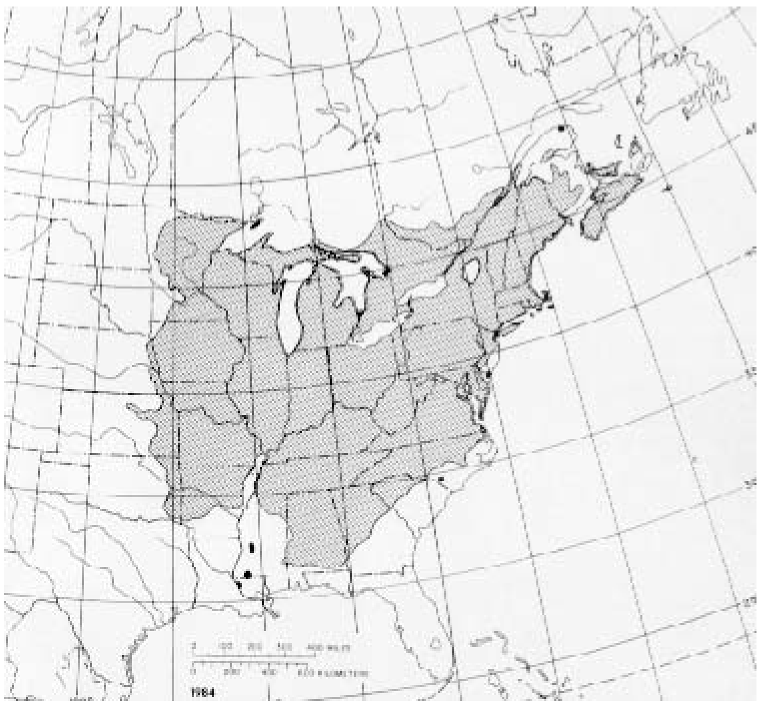

Fig. 1. The native range of Northern red oak (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/quercus/rubra.htm. June 27, 2006)

Northern red oak is a moderate to fast growing tree. At maturity northern red oak typically reaches heights of 65 to 98 feet and diameters of 24 to 36 inches. Site indexes range up to 80 feet on a base age 50 curve. Northern red oak is classified as intermediate in shade tolerance, and responds well to release if the released trees are above average in the intermediate crown class or above. In stands greater than 30 years old epicormic branching can be prolific following heavy thinnings (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/quercus/rubra.htm. June 27, 2006).

Northern red oak is used for a variety of products including lumber, plywood, and veneer. It is a popular shade, and ornamental tree that is easily transplanted. The acorns it produces are an important food for squirrels, deer, turkey, mice, voles, and other mammals and birds (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/quercus/rubra.htm. June 27, 2006).

Species Northern red oak Region Central states

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 4.50, 5.40, and 6.30 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 25 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183482143 and 0.446428571, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Myers et al. (1980) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$Y = 0.05629D^{2.29601}H^{0.92143}$$

where

Y = the green weight of the total tree (lb.)

D = diameter at breast height (in.)

H = total tree height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be \$301/mbf (International 1/4) (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005) and pulpwood price was assumed to be \$16/cord (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005). The price of carbon was assumed to be \$0, \$10, \$37 or \$50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of northern red oak plantations in the Central States.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$152.60	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]The seedling cost was estimated based on the seedling prices from Ohio DNR Division of Forestry (http://www.ohiodnr.com/forestry/seedling/pdf/seedling_order_form06.pdf. January 18,2006), Minnesota DNR State Forest Nursery (http://www.dnr.state.mn.us/forestry/nurseries/pricelist.html. January 18, 2006) and Lee's Nursery, Inc. (http://www.leenursery.com/Seedling2006Catalog.pdf. January 18, 2006).

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Table 1. Total tons of carbon sequestered per acre for Northern red oak plantations in the central states United States by site index and real alternative rates of return. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	30.84	28.55	23.98	21.76	21.76	21.31
80	35.13	29.68	26.04	23.47	23.36	23.36
90	40.6	31.42	27.79	27.13	27.13	25.29

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for Northern red oak plantations in the central states United States by site index and real alternative rates of return. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	31.21	28.55	24.72	21.86	21.86	21.86
80	35.13	29.68	26.04	26.04	23.46	23.46
90	41.04	35.33	28.50	28.50	27.31	26.00

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for Northern red oak plantations in the central states United States by site index and real alternative rates of return. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	32.31	28.94	24.92	24.92	24.37	23.72
80	36.61	34.88	30.57	30.00	26.17	25.98
90	41.70	37.41	33.64	32.25	28.73	28.49

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for Northern red oak plantations in the central states United States by site index and real alternative rates of return. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	32.31	28.94	28.95	24.92	24.05	23.55
80	36.61	34.87	30.57	30.57	26.17	26.17
90	41.7	37.41	33.64	33.2	29.47	29.49

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Northern red oak plantations by site index and real alternative rates of return in the central states United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	44-69-**84**[2] (30%)	<44-69-**78**> (30%)[3]	<40-45-**67**>[4] (30%)	<40-45-**61**> (30%)	<40-45-**61**> (30%)	<40-45-**60**> (30%)
80	38-65-**83** (30%)	<38-65-**71**> (30%)	<37-43-**63**> (30%)	<35-41-**58**> (30%)	<35-40-**58**> (30%)	<35-40-**58**> (30%)
90	41-65-**85** (30%)	<32-62-**67**> (30%)	<32-37-**60**> (30%)	<32-37-**59**> (30%)	<32-37-**59**> (30%)	<32-37-**55**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Northern red oak plantations by site index and real alternative rates of return in the central states United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	44-69-**85**[2] (30%)[3]	<44-69-**78**>[4] (30%)	<43-48-**67**> (30%)	<41-46-**61**> (30%)	<41-46-**61**> (30%)	<41-46-**61**> (30%)
80	38-65-**83** (30%)	<38-65-**71>** (30%)	<37-43-**63**> (30%)	<37-43-**63**> (30%)	<37-43-**57**> (30%)	<37-43-**57**> (30%)
90	41-65-**86** (30%)	<42-62-**73>** (30%)	<37-42-**59**> (30%)	<37-42-**59**> (30%)	<32-38-**59**> (30%)	<33-38-**56**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Northern red oak plantations by site index and real alternative rates of return in the central states United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	53-73-**87**[2] (30%)[3]	51-71-**78** (30%)	<52-**69>**[4] (25%)	<52-**69**> (25%)	<52-**67**> (25%)	<54-**67**> (20%)
80	48-67-**85** (30%)	49-68-**81** (30%)	<50-65-**71>** (30%)	<50-65-**70>** (30%)	<50-**65**> (30%)	<50-**63**> (20%)
90	47-64-**85** (30%)	47-61-**75** (30%)	<47-61-**68>** (30%)	<47-61-**66>** (30%)	<49-**61**> (20%)	<48-**60**> (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for Northern red oak plantations by site index and real alternative rates of return in the central states United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	53-73-**87**[2] (30%)[3]	51-71-**78** (30%)	<52-70-**78>** (30%)	<52-**69>** (25%)	<55-**69**>[4] (20%)	<58-**69**> (20%)
80	48-67-**85** (30%)	50-68-**81** (30%)	<50-65-**71>** (30%)	<50-65-**71>** (30%)	<50-**64>** (20%)	<50-**64**> (20%)
90	47-64-**85** (30%)	47-61-**75** (30%)	47-61-**68** (30%)	<48-63-**68>** (25%)	<51-**65>** (20%)	<52-**65**> (20%)

[1] Base age 50.
[2] Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3] Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4] Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for Northern red oak plantations by site index and real alternative rates of return in the central states United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$539.48	-$256.68	-$370.45	-$392.45	-$397.42	-$398.08
80	$744.44	-$209.11	-$357.02	-$388.57	-$395.93	-$397.50
90	$934.76	-$167.30	-$342.59	-$383.72	-$394.29	-$396.73

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for Northern red oak plantations by site index and real alternative rates of return in the central states United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$736.27	-$155.96	-$316.18	-$359.52	-$375.74	-$383.18
80	$970.48	-$92.97	-$292.32	-$348.18	-$368.69	-$378.43
90	$1,204.65	-$35.52	-$268.42	-$336.23	-$362.22	-$374.16

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for Northern red oak plantations by site index and real alternative rates of return in the central states United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,280.81	$121.67	-$163.16	-$266.94	-$315.84	-$342.32
80	$1,607.24	$232.50	-$105.79	-$232.85	-$292.79	-$325.87
90	$1,931.39	$347.43	-$50.44	-$200.09	-$271.62	-$311.12

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for Northern red oak plantations by site index and real alternative rates of return in the central states United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,545.90	$256.39	-$87.81	-$221.64	-$286.69	-$322.53
80	$1,913.56	$396.17	-$14.15	-$176.29	-$255.82	-$300.40
90	$2,284.93	$532.83	$56.28	-$133.42	-$227.53	-$280.58

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for Northern red oak plantations by site index and real alternative rates of return in the central states United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$614.85	-$262.24	-$373.18	-$393.52	-$397.69	-$398.16
80	$851.43	-$215.54	-$360.55	-$389.98	-$396.31	-$397.61
90	$1,061.75	-$173.59	-$346.80	-$384.99	-$394.63	-$396.89

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for Northern red oak plantations by site index and real alternative rates of return in the central states United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$836.30	-$159.34	-$318.51	-$360.50	-$375.99	-$383.24
80	$1,109.96	-$95.83	-$295.20	-$348.96	-$369.09	-$378.55
90	$1,363.79	-$36.51	-$271.97	-$337.34	-$362.53	-$374.29

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for Northern red oak plantations by site index and real alternative rates of return in the central states United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,445.35	$124.31	-$164.20	-$267.28	-$315.94	-$342.34
80	$1,825.59	$236.83	-$106.37	-$233.12	-$292.92	-$325.91
90	$2,193.77	$356.17	-$50.78	-$200.42	-$271.80	-$311.18

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for Northern red oak plantations by site index and real alternative rates of return in the central states United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,744.49	$261.94	-$88.10	-$221.92	-$286.77	-$322.55
80	$2,173.52	$403.56	-$14.22	-$176.48	-$255.94	-$300.44
90	$2,595.35	$546.22	$56.67	-$133.60	-$227.62	-$280.61

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for Northern red oak plantations by soil productivity and real alternative rates of return in the central states United States. (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	44-69-**84**[2] (30%)[3]	769.65	0	812.54	2.67	1439.52	18.71	3021.71	21.39
	5.00%	<44-69-**78**> (30%)[3]	769.65	0	812.54	2.67	1404.21	15.69	2986.40	18.37
	7.50%	<40-45-**67**> (30%)	599.19	0	595.12	0	1794.48	11.20	2988.79	11.20
	10.00%	<40-45-**61**> (30%)	599.19	0	595.12	0	1979.45	7.33	3173.76	7.33
	12.50%	<40-45-**61**> (30%)	599.19	0	595.12	0	1979.45	7.33	3173.76	7.33
	15.00%	<40-45-**60**> (30%)	599.19	0	595.12	0	1973.6	6.53	3167.91	6.53
80	2.50%	38-65-**83** (30%)	685.04	0	833.82	2.66	1502.66	22.83	3021.52	25.49
	5.00%	<38-65-**71**> (30%)	685.04	0	833.82	2.66	1503.16	15.13	3022.02	17.79
	7.50%	<37-43-**63**> (30%)	658.41	0	707.17	0.00	1994.81	11.66	3360.39	11.66
	10.00%	<35-41-**58**> (30%)	554.13	0	624.00	0.00	2172.07	7.45	3350.20	7.45
	12.50%	<35-40-**58**> (30%)	554.13	0	554.25	0.00	2179.87	7.47	3288.25	7.47
	15.00%	<35-40-**58**> (30%)	554.13	0	554.25	0.00	2179.87	7.47	3288.25	7.47
90	2.50%	41-65-**85** (30%)	908.98	0	843.19	3.59	1452.63	27.12	3204.80	30.71
	5.00%	<32-62-**67**> (30%)	570.43	0	992.24	2.58	1720.14	15.30	3282.81	17.88
	7.50%	<32-37-**60**> (30%)	570.43	0	621.68	0.00	2207.41	12.21	3399.52	12.21
	10.00%	<32-37-**59**> (30%)	570.43	0	621.68	0.00	2212.54	11.32	3404.65	11.32
	12.50%	<32-37-**59**> (30%)	570.43	0	621.68	0.00	2212.54	11.32	3404.65	11.32
	15.00%	<32-37-**55**> (30%)	570.43	0	621.68	0.00	2481.16	7.01	3673.27	7.01

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 18. Volume removed from the financially optimal schedules for Northern red oak plantations by soil productivity and real alternative rates of return in the central states United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	44-69-**85**[3] (30%)[4]	769.65	0	812.54	2.67	1448.01	19.19	3030.20	21.86
	5.00%	<44-69-**78**> (30%)	769.65	0	812.54	2.67	1404.21	15.69	2986.40	18.37
	7.50%	<43-48-**67**> (30%)	745.46	0	652.05	0	1799.43	11.25	3196.94	11.25
	10.00%	<41-46-**61**> (30%)	660.09	0	610.28	0	1958.45	7.27	3228.82	7.27
	12.50%	<41-46-**61**> (30%)	660.09	0	610.28	0	1958.45	7.27	3228.82	7.27
	15.00%	<41-46-**61**> (30%)	660.09	0	610.28	0	1958.45	7.27	3228.82	7.27
80	2.50%	38-65-**83** (30%)	685.04	0	833.82	2.66	1502.66	22.83	3021.52	25.49
	5.00%	<38-65-**71>** (30%)	685.04	0	833.82	2.66	1503.16	15.13	3022.02	17.79
	7.50%	<37-43-**63**> (30%)	658.41	0	707.17	0	1994.81	11.66	3360.39	11.66
	10.00%	<37-43-**63**> (30%)	658.41	0	707.17	0	1994.81	11.66	3360.39	11.66
	12.50%	<37-43-**57**> (30%)	658.41	0	707.17	0	2114.12	6.81	3479.70	6.81
	15.00%	<37-43-**57**> (30%)	658.41	0	707.17	0	2114.12	6.81	3479.70	6.81
90	2.50%	41-65-**86** (30%)	908.98	0	843.19	3.59	1417.32	27.85	3169.49	31.44
	5.00%	<42-62-**73>** (30%)	939.40	0	882.25	2.75	1528.35	19.64	3350.00	22.40
	7.50%	<37-42-**59**> (30%)	714.05	0	712.42	0	2159.79	11.43	3586.26	11.43
	10.00%	<37-42-**59**> (30%)	714.05	0	712.42	0	2159.79	11.43	3586.26	11.43
	12.50%	<32-38-**59**> (30%)	570.43	0	652.95	0	2208.66	11.31	3432.04	11.31
	15.00%	<33-38-**56**> (30%)	605.33	0	646.70	0	2364.18	8.15	3616.21	8.15

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 19. Volume removed from the financially optimal schedules for Northern red oak plantations by soil productivity and real alternative rates of return in the central states United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	53-73-**87**[3] (30%)[4]	981.30	0	755.55	3.34	1386.51	19.22	3123.36	22.57
	5.00%	51-71-**78** (30%)	931.09	0	803.93	3.01	1350.73	15.14	3085.75	18.15
	7.50%	<52-**69>** (25%)	780.39	0	[5]-	-	2269.53	12.40	3049.92	12.40
	10.00%	<52-**69**> (25%)	780.39	0	-	-	2269.53	12.40	3049.92	12.40
	12.50%	<52-**67**> (25%)	780.39	0	-	-	2420.24	10.73	3200.63	10.73
	15.00%	<54-**67**> (20%)	640.98	0	-	-	2550.41	10.00	3191.39	10.00
80	2.50%	48-67-**85** (30%)	1016.08	0.00	780.62	3.15	1432.41	23.09	3229.11	26.24
	5.00%	49-68-**81** (30%)	1062.00	0.00	766.28	3.32	1445.12	20.51	3273.40	23.83
	7.50%	<50-65-**71>** (30%)	1100.11	0.00	804.67	2.51	1442.28	14.67	3347.06	17.18
	10.00%	<50-65-**70>** (30%)	1100.11	0.00	804.67	2.51	1479.34	13.77	3384.12	16.28
	12.50%	<50-**65**> (30%)	732.91	0.00	-	-	2717.86	11.29	3450.77	11.29
	15.00%	<50-**63**> (20%)	732.91	0.00	-	-	2824.26	10.45	3557.17	10.45
90	2.50%	47-64-**85** (30%)	1091.46	0	875.50	3.24	1447.15	27.25	3414.11	30.49
	5.00%	47-61-**75** (30%)	1091.46	0	916.76	2.42	1579.36	21.28	3587.58	23.70
	7.50%	<47-61-**68>** (30%)	1091.46	0	916.76	2.42	1686.74	15.74	3694.96	18.16
	10.00%	<47-61-**66>** (30%)	1091.46	0	916.76	2.42	1640.97	14.29	3649.19	16.71
	12.50%	<49-**61**> (20%)	749.51	0	-	-	2981.61	11.63	3731.12	11.63
	15.00%	<48-**60**> (20%)	728.75	0	-	-	3092.73	10.60	3821.48	10.60

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for sugar maple plantations by soil productivity and real alternative rates of return in the central states United States. (carbon value = $50/ton)

Site Index[1]	ARR	Schedule	1st thinning Cu. Ft.	1st thinning MBF[2]	2nd thinning Cu. Ft.	2nd thinning MBF	Final Harvest Cu. Ft.	Final Harvest MBF	Total Volume Cu. Ft.	Total Volume MBF
70	2.50%	53-73-**87**[3] (30%)[4]	981.30	0	755.55	3.34	1386.51	19.22	3123.36	22.57
	5.00%	51-71-**78** (30%)	931.09	0	803.93	3.01	1350.73	15.14	3085.75	18.15
	7.50%	<52-70-**78**> (30%)	962.36	0	789.31	2.81	1351.70	15.15	3103.37	17.96
	10.00%	<52-**69**> (25%)	780.39	0	[5]-	-	2269.53	12.40	3049.92	12.40
	12.50%	<55-**69**> (20%)	673.14	0	-	-	2335.92	11.82	3009.06	11.82
	15.00%	<58-**69**> (20%)	711.15	0	-	-	2244.83	11.71	2955.98	11.71
80	2.50%	48-67-**85** (30%)	1016.08	0	780.62	3.15	1432.41	23.09	3229.11	26.24
	5.00%	50-68-**81** (30%)	1100.11	0	758.91	3.31	1433.86	20.40	3292.88	23.71
	7.50%	<50-65-**71**> (30%)	1100.11	0	804.67	2.51	1442.28	14.67	3347.06	17.18
	10.00%	<50-65-**71**> (30%)	1100.11	0	804.67	2.51	1442.28	14.67	3347.06	17.18
	12.50%	<50-**64**> (20%)	732.91	0	-	-	2717.86	11.29	3450.77	11.29
	15.00%	<50-**64**> (20%)	732.91	0	-	-	2717.86	11.29	3450.77	11.29
90	2.50%	47-64-**85** (30%)	1091.46	0	875.50	3.24	1447.15	27.25	3414.11	30.49
	5.00%	47-61-**75** (30%)	1091.46	0	916.76	2.42	1579.36	21.28	3587.58	23.70
	7.50%	47-61-**68** (30%)	1091.46	0	916.76	2.42	1686.74	15.74	3694.96	18.16
	10.00%	<48-63-**68**> (25%)	1134.50	0	882.03	2.92	1596.41	15.12	3612.94	18.05
	12.50%	<51-**65**> (20%)	784.79	0	-	-	2555.59	15.31	3340.38	15.31
	15.0%	<52-**65**> (20%)	797.80	0	-	-	2551.62	15.35	3349.42	15.35

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for northern red oak plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	44-69-**84**[2] (30%)	44-69-**85** (30%)	1%	53-73-**87** (30%)	4%	53-73-**87** (30%)	4%
	80	38-65-**83 (**30%**)**	38-65-**83** (30%)	0%	48-67-**85** (30%)	2%	48-67-**85** (30%)	2%
	90	41-65-**85** (30%)	41-65-**86** (30%)	1%	47-64-**85** (30%)	0%	47-64-**85** (30%)	0%
5.00%	70	<44-69-**78>** (30%)[3]	<44-69-**78**> (30%)	4%	51-71-**78** (30%)	4%	51-71-**78** (30%)	4%
	80	<38-65-**71**> (30%)	<38-65-**71>** (30%)	0%	49-68-**81** (30%)	14%	50-68-**81** (30%)	14%
	90	<32-62-**67**> (30%)	<42-62-**73>** (30%)	9%	47-61-**75** (30%)	12%	47-61-**75** (30%)	12%
7.50%	70	<40-45-**67**>[4] (30%)	<43-48-**67**> (30%)	0%	<52-**69>** (25%)	3%	<52-70-**78>** (30%)	16%
	80	<37-43-**63**> (30%)	<37-43-**63**> (30%)	0%	<50-65-**71>** (30%)	13%	<50-65-**71>** (30%)	13%
	90	<32-37-**60**> (30%)	<37-42-**59**> (30%)	-2%	<47-61-**68>** (30%)	13%	47-61-**68** (30%)	13%
10.00%	70	<40-45-**61**> (30%)	<41-46-**61**> (30%)	0%	<52-**69**> (25%)	13%	<52-**69>** (25%)	13%
	80	<35-41-**58**> (30%)	<37-43-**63**> (30%)	9%	<50-65-**70>** (30%)	21%	<50-65-**71>** (30%)	22%
	90	<32-37-**59**> (30%)	<37-42-**59**> (30%)	0%	<47-61-**66>** (30%)	12%	<48-63-**68>** (25%)	15%
12.50%	70	<40-45-**61**> (30%)	<41-46-**61**> (30%)	0%	<52-**67**> (25%)	10%	<55-**69**> (20%)	13%
	80	<35-40-**58**> (30%)	<37-43-**57**> (30%)	-2%	<50-**65**> (30%)	12%	<50-**64>** (20%)	10%
	90	<32-37-**59**> (30%)	<32-38-**59**> (30%)	0%	<49-**61**> (20%)	3%	<51-**65>** (20%)	10%
15.00%	70	<40-45-**60**> (30%)	<41-46-**61**> (30%)	2%	<54-**67**> (20%)	12%	<58-**69**> (20%)	15%
	80	<35-40-**58**> (30%)	<37-43-**57**> (30%)	-2%	<50-**63**> (20%)	9%	<50-**64**> (20%)	10%
	90	<32-37-**55**> (30%)	<33-38-**56**> (30%)	2%	<48-**60**> (20%)	9%	<52-**65**> (20%)	18%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3] Number in parentheses indicates the percentage of basal area removed during thinning

[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for northern red oak plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	614.85	836.30	36%	1,445.35	135%	1,744.49	184%
	80	851.43	1,109.96	30%	1,825.59	114%	2,173.52	155%
	90	1,061.75	1,363.79	28%	2,193.77	107%	2,595.35	144%
5.00%	70	-262.24	-159.34		124.31		261.94	
	80	-215.54	-95.83		236.83		403.56	
	90	-173.59	-36.51		356.17		546.22	
7.50%	70	-373.18	-318.51		-164.20		-88.10	
	80	-360.55	-295.20		-106.37		-14.22	
	90	-346.80	-271.97		-50.78		56.67	
10.00%	70	-393.52	-360.50		-267.28		-221.92	
	80	-389.98	-348.96		-233.12		-176.48	
	90	-384.99	-337.34		-200.42		-133.60	
12.50%	70	-397.69	-375.99		-315.94		-286.77	
	80	-396.31	-369.09		-292.92		-255.94	
	90	-394.63	-362.53		-271.80		-227.62	
15.00%	70	-398.16	-383.24		-342.34		-322.55	
	80	-397.61	-378.55		-325.91		-300.44	
	90	-396.89	-374.29		-311.18		-280.61	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

Central States- Northern red oak - Timber Only Rotations (C = $0/ton)

Northern red oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 69 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 5). This optimal management regime will generate the maximum SEV of $614.85 (Table 13), with a NPW of $539.48 per acre (Table 9). This means that $614.85 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $539.48 per acre for managing one rotation, or $614.85 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,021.71 cubic feet of pulpwood and 21.39 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 30.84 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 69 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 78 (Table 5). This optimal management regime will generate the maximum SEV of -$262.24 (Table 13), with a NPW of -$256.68 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,986.40 cubic feet of pulpwood and 18.37 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 28.55 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 5). This optimal management regime will generate the maximum SEV of -$373.18 (Table 13), with a NPW of -$370.45 per acre (Table 9). This financially optimal rotation would produce an estimated 2,988.79 cubic feet of pulpwood and 11.20 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.98 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 61 (Table 5). This optimal management regime will generate the maximum SEV of -$393.52 (Table 13), with a NPW of -$392.45 per acre (Table 9). This financially optimal rotation would produce an estimated 3,173.76 cubic feet of pulpwood and 7.33 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 21.76 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 61 (Table 5). This optimal management regime will generate the maximum SEV of -$397.69 (Table 13), with a NPW of -$397.42 per acre (Table 9). This financially optimal rotation would produce an estimated 3,173.76 cubic feet of pulpwood and 7.33 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 21.76 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$398.16 (Table 13), with a NPW of -$398.08 per acre (Table 9). This financially optimal rotation would produce an estimated 3,167.91 cubic feet of pulpwood and 6.53 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 21.31 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 65 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 5). This optimal management regime will generate the maximum SEV of $851.43 (Table 13), with a NPW of $744.44 per acre (Table 9). This financially optimal rotation would produce an estimated 3,021.52 cubic feet of pulpwood and 25.49 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 35.13 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 65 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 5). This optimal management regime will generate the maximum SEV of -$215.54 (Table 13), with a NPW of -$209.11 per acre (Table 9). This financially optimal rotation would produce an estimated 3,022.02 cubic feet of pulpwood and 17.79 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 29.68 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 43 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 63 (Table 5). This optimal management regime will generate the maximum SEV of -$360.55 (Table 13), with a NPW of -$357.02 per acre (Table 9). This financially optimal rotation would produce an estimated 3,360.39 cubic feet of pulpwood and 11.66 MBF of sawlogs per

acre from the thinning and final harvest (Table 17), and sequester 26.04 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 5). This optimal management regime will generate the maximum SEV of -$389.98 (Table 13), with a NPW of -$388.57 per acre (Table 9). This financially optimal rotation would produce an estimated 3,350.20 cubic feet of pulpwood and 7.45 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.47 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 5). This optimal management regime will generate the maximum SEV of -$396.31 (Table 13), with a NPW of -$395.93 per acre (Table 9). This financially optimal rotation would produce an estimated 3,288.25 cubic feet of pulpwood and 7.47 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.36 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 5). This optimal management regime will generate the maximum SEV of -$397.61 (Table 13), with a NPW of -$397.50 per acre (Table 9). This financially optimal rotation would produce an estimated 3,288.25 cubic feet of pulpwood and 7.47 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.36 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 65 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 5). This optimal management regime will generate the maximum SEV of $1,061.75 (Table 13), with a NPW of $934.76 per acre (Table 9). This financially optimal rotation would produce an estimated 3,204.80 cubic feet of pulpwood and 30.71 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 40.60 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 62 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 5).

This optimal management regime will generate the maximum SEV of -$173.59 (Table 13), with a NPW of -$167.30 per acre (Table 9). This financially optimal rotation would produce an estimated 3,282.81 cubic feet of pulpwood and 17.88 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 31.42 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 37 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$346.80 (Table 13), with a NPW of -$342.59 per acre (Table 9). This financially optimal rotation would produce an estimated 3,399.52 cubic feet of pulpwood and 12.21 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 27.79 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 37 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 5). This optimal management regime will generate the maximum SEV of -$384.99 (Table 13), with a NPW of -$383.72 per acre (Table 9). This financially optimal rotation would produce an estimated 3,404.65 cubic feet of pulpwood and 11.32 MBF of sawlogs per

acre from the thinning and final harvest (Table 17), and sequester 27.13 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 37 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 5). This optimal management regime will generate the maximum SEV of -$394.63 (Table 13), with a NPW of -$394.29 per acre (Table 9). This financially optimal rotation would produce an estimated 3,404.65 cubic feet of pulpwood and 11.32 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 27.13 net tons of carbon per acre during one rotation (Table 1).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 37 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 5). This optimal management regime will generate the maximum SEV of -$396.89 (Table 13), with a NPW of -$396.73 per acre (Table 9). This financially optimal rotation would produce an estimated 3,673.27 cubic feet of pulpwood and 7.01 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 25.29 net tons of carbon per acre during one rotation (Table 1).

<u>Central States- Northern red oak - Timber Only Rotations (C = $10/ton)</u>

Northern red oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 69 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 6). This optimal management regime will generate the maximum SEV of $836.30 (Table 14), with a NPW of $736.27 per acre (Table 10). This means that $836.30 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $736.27 per acre for managing one rotation, or $836.30 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,030.20 cubic feet of pulpwood and 21.86 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 31.21 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 69 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 78 (Table 6).

This optimal management regime will generate the maximum SEV of -$159.34 (Table 14), with a NPW of -$155.96 per acre (Table 10). This financially optimal rotation would produce an estimated 2,986.40 cubic feet of pulpwood and 18.37 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 28.55 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 6 (Table 6). This optimal management regime will generate the maximum SEV of -$318.51 (Table 14), with a NPW of -$316.18 per acre (Table 10). This financially optimal rotation would produce an estimated 3,196.94 cubic feet of pulpwood and 11.25 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 24.72 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 61 (Table 6). This optimal management regime will generate the maximum SEV of -$360.50 (Table 14), with a NPW of -$259.52 per acre (Table 10). This financially optimal rotation would produce an estimated 3,228.82 cubic feet of pulpwood and 7.27 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 21.86 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 61 (Table 6). This optimal management regime will generate the maximum SEV of -$375.99 (Table 14), with a NPW of -$375.74 per acre (Table 10). This financially optimal rotation would produce an estimated 3,228.82 cubic feet of pulpwood and 7.27 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 21.86 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 61 (Table 6). This optimal management regime will generate the maximum SEV of -$383.24 (Table 14), with a NPW of -$383.18 per acre (Table 10). This financially optimal rotation would produce an estimated 3,228.82 cubic feet of pulpwood and 7.27 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 21.86 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 65 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 6). This optimal management regime will generate the maximum SEV of $1,109.96 (Table 14), with a NPW of $970.48 per acre (Table 10). This financially optimal rotation would produce an estimated 3,021.52 cubic feet of pulpwood and 25.49 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 35.13 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 65 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 6). This optimal management regime will generate the maximum SEV of -$95.83 (Table 14), with a NPW of -$92.97 per acre (Table 10). This financially optimal rotation would produce an estimated 3,022.02 cubic feet of pulpwood and 17.79 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 29.68 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 43 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 63 (Table 6). This optimal management regime will generate the maximum SEV of -$295.20 (Table 14), with a NPW of -$292.32 per acre (Table 10). This financially optimal rotation would produce an estimated 3,360.39 cubic feet of pulpwood and 11.66 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.04 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 43 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 63 (Table 6). This optimal management regime will generate the maximum SEV of -$348.96 (Table 14), with a NPW of -$348.18 per acre (Table 10). This financially optimal rotation would produce an estimated 3,360.39 cubic feet of pulpwood and 11.66 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.04 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 43 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 6).

This optimal management regime will generate the maximum SEV of -$369.09 (Table 14), with a NPW of -$368.69 per acre (Table 10). This financially optimal rotation would produce an estimated 3,479.70 cubic feet of pulpwood and 6.81 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.46 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 43 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 6). This optimal management regime will generate the maximum SEV of -$378.55 (Table 14), with a NPW of -$378.43 per acre (Table 10). This financially optimal rotation would produce an estimated 3,479.70 cubic feet of pulpwood and 6.81 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.46 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 65 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 86 (Table 6). This optimal management regime will generate the maximum SEV of $1,363.79 (Table 14), with a NPW of $1,204.65 per acre (Table 10). This financially optimal rotation would produce an estimated 3,169.49 cubic feet of pulpwood and 31.44 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 41.04 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 62 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 73 (Table 6). This optimal management regime will generate the maximum SEV of -$36.51 (Table 14), with a NPW of -$35.52 per acre (Table 10). This financially optimal rotation would produce an estimated 3,350.00 cubic feet of pulpwood and 22.40 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 35.33 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 42 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 6). This optimal management regime will generate the maximum SEV of -$271.97 (Table 14), with a NPW of -$268.42 per acre (Table 10). This financially optimal rotation would produce an estimated 3,586.26 cubic feet of pulpwood and 11.43 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 28.50 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 42 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 6). This optimal management regime will generate the maximum SEV of -$337.34 (Table 14), with a NPW of -$336.23 per acre (Table 10). This financially optimal rotation would produce an estimated 3,586.26 cubic feet of pulpwood and 11.43 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 28.50 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 38 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 6). This optimal management regime will generate the maximum SEV of -$362.53 (Table 14), with a NPW of -$362.22 per acre (Table 10). This financially optimal rotation would produce an estimated 3,432.04 cubic feet of pulpwood and 11.31 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 27.31 net tons of carbon per acre during one rotation (Table 2).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 6). This optimal management regime will generate the maximum SEV of -$374.29 (Table 14), with a NPW of -$374.16 per acre (Table 10). This financially optimal rotation would produce an estimated 3,616.21 cubic feet of pulpwood and 8.15 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.00 net tons of carbon per acre during one rotation (Table 2).

<u>Central States-Northern red oak - Timber Only Rotations (C = $37/ton)</u>

Northern red oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 53 and 73 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 7). This optimal management regime will generate the maximum SEV of $1,445.35 (Table 15), with a NPW of $1,280.81 per acre (Table 11). This means that $1,445.35 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,280.81 per acre for managing one rotation, or $1,445.35 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would

produce an estimated 3,123.36 cubic feet of pulpwood and 22.57 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 32.31 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 57 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 78 (Table 7). This optimal management regime will generate the maximum SEV of $124.31 (Table 15), with a NPW of $121.67 per acre (Table 11). This financially optimal rotation would produce an estimated 3,085.75 cubic feet of pulpwood and 18.15 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 28.39 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 52 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 7). This optimal management regime will generate the maximum SEV of -$164.20 (Table 15), with a NPW of -$163.16 per acre (Table 11). This financially optimal rotation would produce an estimated 3,049.92 cubic feet of pulpwood and 12.40 MBF of sawlogs per

acre from the thinning and final harvest (Table 19), and sequester 24.92 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 52 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 7). This optimal management regime will generate the maximum SEV of -$267.28 (Table 15), with a NPW of -$266.94 per acre (Table 11). This financially optimal rotation would produce an estimated 3,049.92 cubic feet of pulpwood and 12.40 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 24.92 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 52 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 7). This optimal management regime will generate the maximum SEV of -$315.94 (Table 15), with a NPW of -$315.84 per acre (Table 11). This financially optimal rotation would produce an estimated 3,200.63 cubic feet of pulpwood and 10.73 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 24.37 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 54 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 7). This optimal management regime will generate the maximum SEV of -$342.34 (Table 15), with a NPW of -$342.32 per acre (Table 11). This financially optimal rotation would produce an estimated 3,191.39 cubic feet of pulpwood and 10.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.72 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 67 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 7). This optimal management regime will generate the maximum SEV of $1,825.59 (Table 15), with a NPW of $1,607.24 per acre (Table 11). This financially optimal rotation would produce an estimated 3,229.11 cubic feet of pulpwood and 26.24 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 36.61 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 49 and 68 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 7). This optimal management regime will generate the maximum SEV of $236.83 (Table 15), with a NPW of $232.50 per acre (Table 11). This financially optimal rotation would produce an estimated 3,273.40 cubic feet of pulpwood and 23.83 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 34.88 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 65 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 7). This optimal management regime will generate the maximum SEV of -$106.37 (Table 15), with a NPW of -$105.79 per acre (Table 11). This financially optimal rotation would produce an estimated 3,347.06 cubic feet of pulpwood and 17.18 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 30.57 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 65 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 70 (Table 7).

This optimal management regime will generate the maximum SEV of -$233.12 (Table 15), with a NPW of -$232.85 per acre (Table 11). This financially optimal rotation would produce an estimated 3,384.12 cubic feet of pulpwood and 16.28 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 30.00 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 50 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 7). This optimal management regime will generate the maximum SEV of -$292.92 (Table 15), with a NPW of -$292.79 per acre (Table 11). This financially optimal rotation would produce an estimated 3,450.77 cubic feet of pulpwood and 11.29 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.17 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 50 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 63 (Table 7). This optimal management regime will generate the maximum SEV of -$325.91 (Table 15), with a NPW of -$325.87 per acre (Table 11). This financially optimal rotation would produce an estimated 3,557.17 cubic feet of pulpwood and 10.45 MBF of sawlogs per

acre from the thinning and final harvest (Table 19), and sequester 25.98 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 64 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 7). This optimal management regime will generate the maximum SEV of $2,193.77 (Table 15), with a NPW of $1,931.39 per acre (Table 11). This financially optimal rotation would produce an estimated 3,414.11 cubic feet of pulpwood and 30.49 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 41.70 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 61 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 7). This optimal management regime will generate the maximum SEV of $356.17 (Table 15), with a NPW of $347.43 per acre (Table 11). This financially optimal rotation would produce an estimated 3,587.58 cubic feet of pulpwood and 23.70 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 37.41 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 61 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 7). This optimal management regime will generate the maximum SEV of -$50.78 (Table 15), with a NPW of -$50.44 per acre (Table 11). This financially optimal rotation would produce an estimated 3,694.96 cubic feet of pulpwood and 18.16 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 33.64 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 61 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 7). This optimal management regime will generate the maximum SEV of -$200.42 (Table 15), with a NPW of -$200.09 per acre (Table 11). This financially optimal rotation would produce an estimated 3,649.19 cubic feet of pulpwood and 16.71 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 32.25 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 49 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 61 (Table 7). This optimal management regime will generate the maximum SEV of -$271.80 (Table 15), with a NPW of -$271.62 per acre (Table 11). This financially optimal rotation would produce an estimated 3,731.12 cubic feet of pulpwood and 11.63 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 28.73 net tons of carbon per acre during one rotation (Table 3).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 48 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$311.18 (Table 15), with a NPW of -$311.12 per acre (Table 11). This financially optimal rotation would produce an estimated 3,821.48 cubic feet of pulpwood and 10.60 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 28.49 net tons of carbon per acre during one rotation (Table 3).

Central States- Northern red oak - Timber Plus Carbon Rotations (C = $50/ton)

Northern red oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 53 and 73 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 8). This optimal management regime will generate the maximum SEV of $1,744.49 (Table 16), with a NPW of $1,545.90 per acre (Table 12). This means that $1,744.49 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,545.90 per acre for managing one rotation, or $1,744.49 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,123.36 cubic feet of pulpwood and 22.57 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 32.31 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 57 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 78 (Table 8).

This optimal management regime will generate the maximum SEV of $261.94 (Table 16), with a NPW of $256.39 per acre (Table 12). This financially optimal rotation would produce an estimated 3,085.75 cubic feet of pulpwood and 18.15 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 28.94 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 70 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 78 (Table 8). This optimal management regime will generate the maximum SEV of -$88.10 (Table 16), with a NPW of -$87.81 per acre (Table 12). This financially optimal rotation would produce an estimated 3,103.37 cubic feet of pulpwood and 17.96 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 28.95 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 52 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 8). This optimal management regime will generate the maximum SEV of -$221.92 (Table 16), with a NPW of -$221.64 per acre (Table 12). This financially optimal rotation would produce an estimated 3,049.92 cubic feet of pulpwood and 12.40 MBF of sawlogs per

acre from the thinning and final harvest (Table 20), and sequester 24.92 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 55 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 8). This optimal management regime will generate the maximum SEV of -$286.77 (Table 16), with a NPW of -$286.69 per acre (Table 12). This financially optimal rotation would produce an estimated 3,009.06 cubic feet of pulpwood and 11.82 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 24.05 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 58 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 8). This optimal management regime will generate the maximum SEV of -$322.55 (Table 16), with a NPW of -$322.53 per acre (Table 12). This financially optimal rotation would produce an estimated 2,955.98 cubic feet of pulpwood and 11.71 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.55 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 67 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 8). This optimal management regime will generate the maximum SEV of $2,173.52 (Table 16), with a NPW of $1,913.56 per acre (Table 12). This financially optimal rotation would produce an estimated 3,229.11 cubic feet of pulpwood and 26.24 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 36.61 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 68 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 8). This optimal management regime will generate the maximum SEV of $403.56 (Table 16), with a NPW of $396.17 per acre (Table 12). This financially optimal rotation would produce an estimated 3,292.88 cubic feet of pulpwood and 23.71 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 34.87 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 65 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 8). This optimal management regime will generate the maximum SEV of -$14.22 (Table 16), with a NPW of -$14.15 per acre (Table 12). This financially optimal rotation would produce an estimated 3,347.06 cubic feet of pulpwood and 17.18 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 30.57 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 65 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 8). This optimal management regime will generate the maximum SEV of -$176.48 (Table 16), with a NPW of -$176.29 per acre (Table 12). This financially optimal rotation would produce an estimated 3,347.06 cubic feet of pulpwood and 17.18 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 30.57 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 50 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 8). This

optimal management regime will generate the maximum SEV of -$255.94 (Table 16), with a NPW of -$255.82 per acre (Table 12). This financially optimal rotation would produce an estimated 3,450.77 cubic feet of pulpwood and 11.29 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 26.17 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 50 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 8). This optimal management regime will generate the maximum SEV of -$300.44 (Table 16), with a NPW of -$300.40 per acre (Table 12). This financially optimal rotation would produce an estimated 3,450.77 cubic feet of pulpwood and 11.29 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 26.17 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 64 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 8). This optimal management regime will generate the maximum SEV of $2,595.35 (Table 16), with a NPW of $2,284.93 per acre (Table 12). This financially optimal rotation would produce an estimated 3,414.11 cubic feet of pulpwood and 30.49 MBF of sawlogs

per acre from the thinning and final harvest (Table 20), and sequester 41.70 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 61 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 8). This optimal management regime will generate the maximum SEV of $546.22 (Table 16), with a NPW of $532.83 per acre (Table 12). This financially optimal rotation would produce an estimated 3,587.58 cubic feet of pulpwood and 23.70 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 37.41 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 61 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 8). This optimal management regime will generate the maximum SEV of $56.67 (Table 16), with a NPW of $56.28 per acre (Table 12). This financially optimal rotation would produce an estimated 3,694.96 cubic feet of pulpwood and 18.16 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 33.64 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 63 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 8). This optimal management regime will generate the maximum SEV of -$133.60 (Table 16), with a NPW of -$133.42 per acre (Table 12). This financially optimal rotation would produce an estimated 3,612.94 cubic feet of pulpwood and 18.05 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 33.20 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 8). This optimal management regime will generate the maximum SEV of -$227.62 (Table 16), with a NPW of -$227.53 per acre (Table 12). This financially optimal rotation would produce an estimated 3,340.38 cubic feet of pulpwood and 15.31 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.47 net tons of carbon per acre during one rotation (Table 4).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 52 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 8). This optimal management regime will generate the maximum SEV of -$280.61 (Table 16), with a NPW of -$280.58 per acre (Table 12). This financially optimal rotation would produce an estimated 3,349.42 cubic feet of pulpwood and 15.35 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.49 net tons of carbon per acre during one rotation (Table 4).

Species Northern red oak Region Lake States

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 6.85, 8.35, and 10 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 25 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183553598 and 0.489476260, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Chapman et al. (1991) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$Y = -2.972+2.873\ln X$$

where

Y = total aboveground dry-weight (kg.)

X = diameter at breast height (cm.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $363/mbf (International 1/4) (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005) and pulpwood price was assumed to be $16/cord (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of northern red oak plantations in the Lake States.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$152.60	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]The seedling cost was estimated based on the seedling prices from Ohio DNR Division of Forestry (http://www.ohiodnr.com/forestry/seedling/pdf/seedling_order_form06.pdf. January 18,2006), Minnesota DNR State Forest Nursery (http://www.dnr.state.mn.us/forestry/nurseries/pricelist.html. January 18, 2006) and Lee's Nursery, Inc. (http://www.leenursery.com/Seedling2006Catalog.pdf. January 18, 2006).

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Table 23. Total tons of carbon sequestered per acre for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	24.75	22.78	21.92	21.92	21.04	21.04
80	30.35	26.54	24.18	24.18	24.18	24.18
90	34.13	29.26	27.06	26.57	26.57	26.57

[1]Base age 50.

Table 24. Total tons of carbon sequestered per acre for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	24.75	22.74	21.92	21.92	21.92	21.04
80	30.35	26.54	24.18	24.18	24.22	24.17
90	34.13	29.26	27.06	27.06	26.57	26.57

[1]Base age 50.

Table 25. Total tons of carbon sequestered per acre for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	24.76	25.46	22.59	22.59	22.97	22.97
80	30.35	27.39	27.98	25.51	25.77	25.77
90	34.13	31.92	30.48	30.48	28.24	28.24

[1]Base age 50.

Table 26. Total tons of carbon sequestered per acre for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	24.76	25.60	22.97	22.97	22.97	22.56
80	30.35	28.20	28.19	25.39	25.77	25.77
90	34.13	33.49	30.32	30.32	28.24	28.24

[1]Base age 50.

Table 27. Financially optimal thinning and final harvest schedules which maximize soil expectation value for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	41-76-**86**[2] (30%)[3]	<40-51-**71**>[4](30%)	<40-46-**70**> (30%)	<40-46-**70**> (30%)	<40-46-**65**> (30%)	<40-46-**65**> (30%)
80	33-70-**89** (30%)	<32-39-**73>** (30%)	<32-39-**64**> (30%)	<32-39-**64**> (30%)	<32-39-**64**> (30%)	<32-39-**64**> (30%)
90	30-64-**90** (30%)	<31-36-**66>** (30%)	<31-36-**59**> (30%)	<30-35-**59**> (30%)	<30-35-**59**> (30%)	<30-35-**59**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 28. Financially optimal thinning and final harvest schedules which maximize soil expectation value for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	41-76-**86**[2] (30%)[3]	<40-51-**71**>[4](30%)	<40-46-**70**> (30%)	<40-46-**70**> (30%)	<40-46-**70**> (30%)	<40-46-**65**> (30%)
80	33-70-**89** (30%)	<32-39-**73**> (30%)	<32-39-**64**> (30%)	<32-39-**64**> (30%)	<42-52-**69**> (20%)	<33-39-**64**> (30%)
90	30-64-**90** (30%)	<31-36-**66**> (30%)	<31-36-**59**> (30%)	<31-36-**59**> (30%)	<30-35-**59**> (30%)	<30-35-**59**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 29. Financially optimal thinning and final harvest schedules which maximize soil expectation value for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	40-77-**86**[2] (30%)[3]	55-77-**88** (30%)	<60-73-**79**>[4](20%)	<60-73-**79**> (20%)	<63-74-**80**> (20%)	<63-74-**80**> (20%)
80	33-70-**89** (30%)	33-70-**77** (30%)	<55-72-**80**> (30%)	<57-69-**74**> (20%)	<60-70-**75**> (20%)	<60-70-**75**> (20%)
90	30-64-**90** (30%)	33-64-**79** (30%)	52-67-**73** (30%)	<52-67-**73**> (30%)	<55-**69**> (20%)	<55-**69**> (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 30. Financially optimal thinning and final harvest schedules which maximize soil expectation value for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	40-77-**86**[2] (30%)[3]	58-79-**90** (25%)	63-74-**80** (20%)	<63-74-**80**>[4](20%)	<63-74-**80**> (20%)	<65-74-**80**> (20%)
80	33-70-**89** (30%)	50-73-**81** (25%)	58-74-**82** (25%)	<59-**75**> (20%)	<60-70-**75**> (20%)	<60-70-**75**> (20%)
90	30-64-**90** (30%)	48-68-**81** (30%)	55-70-**76** (20%)	55-70-**76** (20%)	<55-**69**> (20%)	<55-**69**> (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 31. Net present worth of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$170.67	-$315.98	-$384.03	-$396.77	-$398.57	-$398.42
80	$367.39	-$278.81	-$370.82	-$391.94	-$396.75	-$397.63
90	$519.40	-$237.09	-$358.76	-$387.43	-$394.98	-$396.88

[1]Base age 50.

Table 32. Net present worth of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$362.58	-$198.59	-$303.63	-$338.57	-$354.76	-$364.15
80	$601.02	-$140.04	-$275.14	-$321.59	-$324.40	-$355.30
90	$791.38	-$74.19	-$245.31	-$303.22	-$330.02	-$345.54

[1]Base age 50.

Table 33. Net present worth of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$880.88	$129.50	-$83.04	-$179.58	-$235.29	-$271.21
80	$1,231.81	$252.95	-$9.41	-$127.37	-$195.49	-$239.65
90	$1,525.72	$383.65	$71.93	-$69.44	-$151.33	-$204.70

[1]Base age 50.

Table 34. Net present worth of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,130.94	$293.40	$26.22	-$102.04	-$177.46	-$226.35
80	$1,535.53	$444.73	$123.81	-$31.88	-$123.75	-$183.72
90	$1,879.29	$613.44	$231.19	$45.88	-$64.25	-$136.53

[1]Base age 50.

Table 35. Soil expectation value of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$193.22	-$325.68	-$386.30	-$397.22	-$398.73	-$398.46
80	$412.04	-$286.56	-$374.22	-$392.74	-$396.94	-$397.67
90	$580.80	-$246.47	-$363.51	-$388.70	-$395.32	-$396.97

[1]Base age 50.

Table 36. Soil expectation value of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$410.48	-$204.70	-$305.43	-$338.96	-$354.84	-$364.19
80	$674.05	-$142.64	-$277.66	-$322.24	-$324.81	-$355.34
90	$884.93	-$77.12	-$248.55	-$304.22	-$330.48	-$345.62

[1]Base age 50.

Table 37. Soil expectation value of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$997.25	$131.20	-$83.30	-$179.67	-$235.31	-$271.21
80	$1,381.50	$258.70	-$9.44	-$127.47	-$195.51	-$239.66
90	$1,706.07	$391.55	$72.28	-$69.50	-$151.37	-$204.71

[1]Base age 50.

Table 38. Soil expectation value of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the lake states region of the United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,280.34	$296.90	$26.30	-$102.08	-$177.47	-$226.35
80	$1,722.13	$453.03	$124.11	-$31.90	-$123.77	-$183.72
90	$2,101.44	$624.88	$232.07	$45.91	-$64.27	-$136.53

[1]Base age 50.

Table 39. Volume removed from the financially optimal schedules for northern red oak plantations by soil productivity and real alternative rates of return in the lake states region of the United States). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	41-76-**86**[3] (30%)[4]	656.63	0	670.16	2.71	1,304.14	10.80	2,630.93	13.51
	5.0%	40-51-**84** (30%)	645.10	0	736.88	0	1,853.40	7.47	3,235.38	7.47
	7.5%	40-46-**70** (30%)	645.10	0	559.73	0	1,834.94	7.15	3,039.77	7.15
	10.0%	40-46-**70** (30%)	645.10	0	559.73	0	1,834.94	7.15	3,039.77	7.15
	12.5%	40-46-**65** (30%)	645.10	0	559.73	0	2,299.35	4.17	3,504.18	4.17
	15.0%	40-46-**65** (30%)	645.10	0	559.73	0	2,299.35	4.17	3,504.18	4.17
80	2.5%	33-70-**89** (30%)	578.76	0	819.59	2.76	1,572.13	16.17	2,970.48	18.93
	5.0%	32-39-**73** (30%)	556.72	0	615.65	0	1,858.37	11.74	3,030.74	11.74
	7.5%	32-39-**64** (30%)	556.72	0	615.65	0	2,186.79	7.35	3,359.16	7.35
	10.0%	32-39-**64** (30%)	556.72	0	615.65	0	2,186.79	7.35	3,359.16	7.35
	12.5%	32-39-**64** (30%)	556.72	0	615.65	0	2,186.79	7.35	3,359.16	7.35
	15.0%	32-39-**64** (30%)	556.72	0	615.65	0	2,186.79	7.35	3,359.16	7.35
90	2.5%	30-64-**90** (30%)	558.21	0	800.22	2.67	1,617.66	20.35	2,976.09	23.02
	5.0%	31-36-**66** (30%)	574.58	0	591.75	0	2,209.45	11.30	3,375.78	11.30
	7.5%	31-36-**59** (30%)	574.58	0	591.75	0	2,206.53	7.35	3,372.86	7.35
	10.0%	30-35-**59** (30%)	558.21	0	578.10	0	2,166.30	7.23	3,302.61	7.23
	12.5%	30-35-**59** (30%)	558.21	0	578.10	0	2,166.30	7.23	3,302.61	7.23
	15.0%	30-35-**59** (30%)	558.21	0	578.10	0	2,166.30	7.23	3,302.61	7.23

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 40. Volume removed from the financially optimal schedules for northern red oak plantations by soil productivity and real alternative rates of return in the lake states region of the United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	41-76-**86**[3] (30%)[4]	656.63	0	670.16	2.71	1,304.14	10.80	2,630.93	13.51
	5.0%	40-51-**71** (30%)	645.10	0	736.88	0	1,853.40	7.47	3,235.38	7.47
	7.5%	40-46-**70** (30%)	645.10	0	559.73	0	1,834.94	7.15	3,039.77	7.15
	10.0%	40-46-**70** (30%)	645.10	0	559.73	0	1,834.94	7.15	3,039.77	7.15
	12.5%	40-46-**70** (30%)	645.10	0	559.73	0	1,834.94	7.15	3,039.77	7.15
	15.0%	40-46-**65** (30%)	645.10	0	559.73	0	2,299.35	4.17	3,504.18	4.17
80	2.5%	33-70-**89** (30%)	578.76	0	819.59	2.76	1,572.13	16.17	2,970.48	18.93
	5.0%	32-39-**73** (30%)	556.72	0	615.65	0	1,858.37	11.74	3,030.74	11.74
	7.5%	32-39-**64** (30%)	556.72	0	615.65	0	2,186.79	7.35	3,359.16	7.35
	10.0%	32-39-**64** (30%)	556.72	0	615.65	0	2,186.79	7.35	3,359.16	7.35
	12.5%	42-52-**69** (20%)	553.76	0	588.03	0	2,321.65	7.81	3,463.44	7.81
	15.0%	33-39-**64** (30%)	578.76	0	611.17	0	2,168.16	7.28	3,358.09	7.28
90	2.5%	30-64-**90** (30%)	558.21	0	800.22	2.67	1,617.66	20.35	2,976.09	23.02
	5.0%	31-36-**66** (30%)	574.58	0	591.75	0	2,209.45	11.30	3,375.78	11.30
	7.5%	31-36-**59** (30%)	574.58	0	591.75	0	2,206.53	7.35	3,372.86	7.35
	10.0%	31-36-**59** (30%)	574.58	0	591.75	0	2,206.53	7.35	3,372.86	7.35
	12.5%	30-35-**59** (30%)	558.21	0	578.10	0	2,166.30	7.23	3,302.61	7.23
	15.0%	30-35-**59** (30%)	558.21	0	578.10	0	2,166.30	7.23	3,302.61	7.23

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 41. Volume removed from the financially optimal schedules for northern red oak plantations by soil productivity and real alternative rates of return in the lake states region of the United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	40-77-**86**[3] (30%)[4]	645.10	0	683.79	2.77	1,299.97	10.76	2,628.86	13.53
	5.0%	55-77-**88** (30%)	999.83	0	649.55	2.53	1,287.85	10.68	2,937.23	13.21
	7.5%	60-73-**79** (20%)	719.81	0	594.51	1.08	1,902.42	7.68	3,216.74	8.76
	10.0%	60-73-**79** (20%)	719.81	0	594.51	1.08	1,902.42	7.68	3,216.74	8.76
	12.5%	63-74-**80** (20%)	739.47	0	588.81	1.07	1,940.69	7.85	3,268.97	8.92
	15.0%	63-74-**80** (20%)	739.47	0	588.81	1.07	1,940.69	7.85	3,268.97	8.92
80	2.5%	33-70-**89** (30%)	578.76	0	819.59	2.76	1,572.13	16.17	2,970.48	18.93
	5.0%	33-70-**77** (30%)	578.76	0	819.59	2.76	1,670.05	10.55	3,068.40	13.31
	7.5%	55-72-**80** (30%)	1,174.94	0	747.92	2.51	1,576.07	9.97	3,498.93	12.47
	10.0%	57-69-**74** (20%)	809.81	0	586.11	1.06	2,286.10	7.72	3,682.02	8.78
	12.5%	60-70-**75** (20%)	829.66	0	590.06	1.07	2,296.84	7.77	3,724.33	8.84
	15.0%	60-70-**75** (20%)	829.66	0	590.06	1.07	2,296.84	7.77	3,724.33	8.84
90	2.5%	30-64-**90** (30%)	558.21	0	800.22	2.67	1,617.66	20.35	2,978.13	23.02
	5.0%	33-64-**79** (30%)	690.37	0	773.99	2.58	1,639.73	14.61	3,118.70	17.19
	7.5%	52-67-**73** (30%)	1,187.25	0	743.40	2.48	1,804.78	9.46	3,744.89	11.94
	10.0%	52-67-**73** (30%)	1,187.25	0	743.40	2.48	1,804.78	9.46	3,744.89	11.94
	12.5%	55-**69** (20%)	827.59	0	-[5]	-	2,764.53	9.23	3,601.35	9.23
	15.0%	55-**69** (20%)	827.59	0	-	-	2,764.53	9.23	3,601.35	9.23

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 42. Volume removed from the financially optimal schedules for northern red oak plantations by soil productivity and real alternative rates of return in the lake states region of the United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	40-77-**86**[3] (30%)[4]	645.10	0	683.79	2.77	1,299.97	10.76	2,625.99	13.53
	5.0%	58-79-**90** (25%)	871.84	0	581.89	2.17	1,413.72	11.70	2,867.45	13.87
	7.5%	63-74-**80** (20%)	739.47	0	588.81	1.07	1,940.69	7.85	3,268.97	8.92
	10.0%	63-74-**80** (20%)	739.47	0	588.81	1.07	1,940.69	7.85	3,268.97	8.92
	12.5%	63-74-**80** (20%)	739.47	0	588.81	1.07	1,940.69	7.85	3,268.97	8.92
	15.0%	65-74-**80** (20%)	740.42	0	573.02	1.04	1,902.35	7.69	3,215.79	8.73
80	2.5%	33-70-**89** (30%)	578.76	0	819.59	2.76	1,572.13	16.17	2,970.48	18.93
	5.0%	50-73-**81** (25%)	810.17	0	682.85	2.30	1,785.58	11.30	3,278.60	13.60
	7.5%	58-74-**82** (25%)	1,025.16	0	660.60	2.22	1,744.86	11.03	3,430.62	13.25
	10.0%	59-**75** (20%)	829.36	0	-[5]	-	2,772.66	9.34	3,602.02	9.34
	12.5%	60-70-**75** (20%)	829.66	0	590.06	1.07	2,296.84	7.77	3,724.33	8.84
	15.0%	60-70-**75** (20%)	829.66	0	590.06	1.07	2,296.84	7.77	3,724.33	8.84
90	2.5%	30-64-**90** (30%)	558.21	0	800.22	2.67	1,617.66	20.35	2,978.13	23.02
	5.0%	48-68-**81** (30%)	1,111.24	0	766.30	2.58	1,605.51	14.56	3,118.70	17.14
	7.5%	55-70-**76** (20%)	827.59	0	561.06	1.87	2,235.16	11.06	3,744.89	12.93
	10.0%	55-70-**76** (20%)	827.59	0	561.06	1.87	2,235.16	11.06	3,744.89	12.93
	12.5%	55-**69** (20%)	827.59	0	-	-	2,764.53	9.23	3,601.35	9.23
	15.0%	55-**69** (20%)	827.59	0	-	-	2,764.53	9.23	3,601.35	9.23

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 43. Financially optimal thinning and final harvest schedules for northern red oak plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	41-76-**86**[2] (30%)[3]	41-76-**86** (30%)	0%	40-77-**86** (30%)	0%	40-77-**86** (30%)	0%
	80	33-70-**89** (30%)	33-70-**89** (30%)	0%	33-70-**89** (30%)	0%	33-70-**89** (30%)	0%
	90	30-64-**90** (30%)	30-64-**90** (30%)	0%	30-64-**90** (30%)	0%	30-64-**90** (30%)	0%
5.00%	70	<40-51-**71**>[4](30%)	<40-51-**71**>(30%)	0%	55-77-**88** (30%)	24%	58-79-**90** (25%)	27%
	80	<32-39-**73>** (30%)	<32-39-**73>** (30%)	0%	33-70-**77** (30%)	5%	50-73-**81** (25%)	11%
	90	<31-36-**66>** (30%)	<31-36-**66>** (30%)	0%	33-64-**79** (30%)	20%	48-68-**81** (30%)	23%
7.50%	70	<40-46-**70**> (30%)	<40-46-**70>** (30%)	0%	<60-73-**79**>[4](20%)	13%	63-74-**80** (20%)	14%
	80	<32-39-**64**> (30%)	<32-39-**64**> (30%)	0%	<55-72-**80**> (30%)	25%	58-74-**82** (25%)	28%
	90	<31-36-**59**> (30%)	<31-36-**59**> (30%)	0%	52-67-**73** (30%)	24%	55-70-**76** (20%)	29%
10.00%	70	<40-46-**70**> (30%)	<40-46-**70>** (30%)	0%	<60-73-**79**>(20%)	13%	<63-74-**80**>(20%)	14%
	80	<32-39-**64**> (30%)	<32-39-**64**> (30%)	0%	<57-69-**74**> (20%)	16%	<59-**75**> (20%)	17%
	90	<30-35-**59**> (30%)	<31-36-**59**> (30%)	0%	<52-67-**73**> (30%)	24%	55-70-**76** (20%)	29%
12.50%	70	<40-46-**65**> (30%)	<40-46-**70>** (30%)	8%	<63-74-**80**>(20%)	23%	<63-74-**80**> (20%)	23%
	80	<32-39-**64**> (30%)	<42-52-**69**> (20%)	8%	<60-70-**75**> (20%)	17%	<60-70-**75**> (20%)	17%
	90	<30-35-**59**> (30%)	<30-35-**59**> (30%)	0%	<55-**69**> (20%)	17%	<55-**69**> (20%)	17%
15.00%	70	<40-46-**65**> (30%)	<40-46-**65>** (30%)	0%	<63-74-**80**>(20%)	23%	<65-74-**80**> (20%)	23%
	80	<32-39-**64**> (30%)	<33-39-**64**> (30%)	0%	<60-70-**75**> (20%)	17%	<60-70-**75**> (20%)	17%
	90	<30-35-**59**> (30%)	<30-35-**59**> (30%)	0%	<55-**69**> (20%)	17%	<55-**69**> (20%)	17%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3] Number in parentheses indicates the percentage of basal area removed during thinning

[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 44. The soil expectation value ($/acre) of the financially optimal rotations for northern red oak plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	193.22	410.48	112%	997.25	416%	1,280.34	563%
	80	412.04	674.05	64%	1,381.50	235%	1,722.13	318%
	90	580.80	884.93	52%	1,706.07	194%	2,101.44	262%
5.00%	70	-325.68	-204.70		131.20		296.90	
	80	-286.56	-142.64		258.70		453.03	
	90	-246.47	-77.12		391.55		624.88	
7.50%	70	-386.30	-305.43		-83.30		26.30	
	80	-374.22	-277.66		-9.44		124.11	
	90	-363.51	-248.55		72.28		232.07	
10.00%	70	-397.22	-338.96		-179.67		-102.08	
	80	-392.74	-322.24		-127.47		-31.90	
	90	-388.70	-304.22		-69.50		45.91	
12.50%	70	-398.73	-354.84		-235.31		-177.47	
	80	-396.94	-324.81		-195.51		-123.77	
	90	-395.32	-330.48		-151.37		-64.27	
15.00%	70	-398.46	-364.19		-271.21		-226.35	
	80	-397.67	-355.34		-239.66		-183.72	
	90	-396.97	-345.62		-204.71		-136.53	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

Lake States- Northern red oak - Timber Only Rotations (C = $0/ton)

Northern red oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 76 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 86 (Table 27). This optimal management regime will generate the maximum SEV of $193.22 (Table 35), with a NPW of $170.67 per acre (Table 31). This means that $193.22 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $170.67 per acre for managing one rotation, or $193.22 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,630.93 cubic feet of pulpwood and 13.51 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 24.75 net tons of carbon per acre during one rotation (Table 23). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 27). This optimal management regime will generate the maximum SEV of -$325.68 (Table 35), with a NPW of -$315.98 per acre (Table 31). This financially optimal

rotation would produce an estimated 3,235.38 cubic feet of pulpwood and 7.47 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 22.78 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 70 (Table 27). This optimal management regime will generate the maximum SEV of -$386.30 (Table 35), with a NPW of -$384.03 per acre (Table 31). This financially optimal rotation would produce an estimated 3,039.77 cubic feet of pulpwood and 7.15 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 21.92 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 70 (Table 27). This optimal management regime will generate the maximum SEV of -$397.22 (Table 35), with a NPW of -$396.77 per acre (Table 31). This financially optimal rotation would produce an estimated 3,039.77 cubic feet of pulpwood and 7.15 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 21.92 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 27). This optimal management regime will generate the maximum SEV of -$398.73 (Table 35), with a NPW of -$398.57 per acre (Table 31). This financially optimal rotation would produce an estimated 3,504.18 cubic feet of pulpwood and 4.17 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 21.04 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 27). This optimal management regime will generate the maximum SEV of -$398.46 (Table 35), with a NPW of -$398.42 per acre (Table 31). This financially optimal rotation would produce an estimated 3,504.18 cubic feet of pulpwood and 4.17 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 21.04 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 70 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 27). This optimal management regime will generate the maximum SEV of $412.04 (Table 35), with a NPW of $367.39 per acre (Table 31). This financially optimal rotation would produce an estimated 2,970.48 cubic feet of pulpwood and 18.93 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 30.35 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 73 (Table 27). This optimal management regime will generate the maximum SEV of -$286.56 (Table 35), with a NPW of -$278.81 per acre (Table 31). This financially optimal rotation would produce an estimated 3,030.74 cubic feet of pulpwood and 11.74 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 26.54 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 27). This optimal management regime will generate the maximum SEV of -$374.22 (Table 35), with a NPW of -$370.82 per acre (Table 31). This financially optimal rotation would produce an estimated 3,359.16 cubic feet of pulpwood and 7.25 MBF of

sawlogs per acre from the thinning and final harvest (Table 39), and sequester 24.18 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 27). This optimal management regime will generate the maximum SEV of -$392.74 (Table 35), with a NPW of -$391.94 per acre (Table 31). This financially optimal rotation would produce an estimated 3,359.16 cubic feet of pulpwood and 7.35 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 24.18 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 27). This optimal management regime will generate the maximum SEV of -$396.94 (Table 35), with a NPW of -$396.75 per acre (Table 31). This financially optimal rotation would produce an estimated 3,359.16 cubic feet of pulpwood and 7.35 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 24.18 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 27). This optimal management regime will generate the maximum SEV of -$397.67 (Table 35), with a NPW of -$397.63 per acre (Table 31). This financially optimal rotation would produce an estimated 3,359.16 cubic feet of pulpwood and 7.35 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 24.18 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 64 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 27). This optimal management regime will generate the maximum SEV of $580.80 (Table 35), with a NPW of $519.40 per acre (Table 31). This financially optimal rotation would produce an estimated 2,976.09 cubic feet of pulpwood and 23.02 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 34.13 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 36 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table

27). This optimal management regime will generate the maximum SEV of -\$246.47 (Table 35), with a NPW of -\$237.09 per acre (Table 31). This financially optimal rotation would produce an estimated 3,375.78 cubic feet of pulpwood and 11.30 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 29.26 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = \$0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 36 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 27). This optimal management regime will generate the maximum SEV of -\$363.51 (Table 35), with a NPW of -\$358.76 per acre (Table 31). This financially optimal rotation would produce an estimated 3,372.86 cubic feet of pulpwood and 7.35 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 27.06 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = \$0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 27). This optimal management regime will generate the maximum SEV of -\$388.70 (Table 35), with a NPW of -\$387.43 per acre (Table 31). This financially optimal rotation would produce an estimated 3,372.86 cubic feet of pulpwood and 7.35 MBF of

sawlogs per acre from the thinning and final harvest (Table 39), and sequester 27.06 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 27). This optimal management regime will generate the maximum SEV of -$395.32 (Table 35), with a NPW of -$394.98 per acre (Table 31). This financially optimal rotation would produce an estimated 3,372.86 cubic feet of pulpwood and 7.35 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 27.06 net tons of carbon per acre during one rotation (Table 23).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 27). This optimal management regime will generate the maximum SEV of -$396.97 (Table 35), with a NPW of -$396.88 per acre (Table 31). This financially optimal rotation would produce an estimated 3,372.86 cubic feet of pulpwood and 7.35 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 27.06 net tons of carbon per acre during one rotation (Table 23).

Lake States- Northern red oak - Timber Only Rotations (C = $10/ton)

Northern red oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 76 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 86 (Table 28). This optimal management regime will generate the maximum SEV of $410.48 (Table 36), with a NPW of $362.58 per acre (Table 32). This means that $410.48 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $362.58 per acre for managing one rotation, or $410.48 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,630.93 cubic feet of pulpwood and 13.51 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 24.75 net tons of carbon per acre during one rotation (Table 24). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table

28). This optimal management regime will generate the maximum SEV of -$204.70 (Table 36), with a NPW of -$198.59 per acre (Table 32). This financially optimal rotation would produce an estimated 3,235.38 cubic feet of pulpwood and 7.47 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 22.74 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 70 (Table 28). This optimal management regime will generate the maximum SEV of -$305.43 (Table 36), with a NPW of -$303.63 per acre (Table 32). This financially optimal rotation would produce an estimated 3,039.77 cubic feet of pulpwood and 7.15 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 21.92 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 70 (Table 28). This optimal management regime will generate the maximum SEV of -$338.96 (Table 36), with a NPW of -$338.57 per acre (Table 32). This financially optimal rotation would produce an estimated 3,039.77 cubic feet of pulpwood and 7.15 MBF of

sawlogs per acre from the thinning and final harvest (Table 40), and sequester 21.92 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 70 (Table 28). This optimal management regime will generate the maximum SEV of -$354.84 (Table 36), with a NPW of -$354.76 per acre (Table 32). This financially optimal rotation would produce an estimated 3,039.77 cubic feet of pulpwood and 7.15 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 21.92 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 28). This optimal management regime will generate the maximum SEV of -$364.19 (Table 36), with a NPW of -$364.15 per acre (Table 32). This financially optimal rotation would produce an estimated 3,504.18 cubic feet of pulpwood and 4.17 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 21.04 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 70 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 28). This optimal management regime will generate the maximum SEV of $674.05 (Table 36), with a NPW of $601.02 per acre (Table 32). This financially optimal rotation would produce an estimated 2,970.48 cubic feet of pulpwood and 18.93 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 30.35 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 73 (Table 28). This optimal management regime will generate the maximum SEV of -$142.64 (Table 36), with a NPW of -$140.04 per acre (Table 32). This financially optimal rotation would produce an estimated 3,030.74 cubic feet of pulpwood and 11.74 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 26.54 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 28). This optimal management regime will generate the maximum SEV of -$277.66 (Table 36), with a NPW of -$275.14 per acre (Table 32). This financially optimal rotation would produce an estimated 3,359.16 cubic feet of pulpwood and 7.35 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 24.18 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 28). This optimal management regime will generate the maximum SEV of -$322.24 (Table 36), with a NPW of -$321.59 per acre (Table 32). This financially optimal rotation would produce an estimated 3,359.16 cubic feet of pulpwood and 7.35 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 24.18 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 52 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table

28). This optimal management regime will generate the maximum SEV of -$324.81 (Table 36), with a NPW of -$324.40 per acre (Table 32). This financially optimal rotation would produce an estimated 3,463.44 cubic feet of pulpwood and 7.81 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 24.22 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 28). This optimal management regime will generate the maximum SEV of -$355.34 (Table 36), with a NPW of -$355.30 per acre (Table 32). This financially optimal rotation would produce an estimated 3,358.09 cubic feet of pulpwood and 7.28 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 24.17 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 64 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of $884.93 (Table 36), with a NPW of $791.38 per acre (Table 32). This financially optimal rotation would produce an estimated 2,976.09 cubic feet of pulpwood and 23.02 MBF of sawlogs

per acre from the thinning and final harvest (Table 40), and sequester 34.13 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 36 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 28). This optimal management regime will generate the maximum SEV of -$77.12 (Table 36), with a NPW of -$74.19 per acre (Table 32). This financially optimal rotation would produce an estimated 3,375.78 cubic feet of pulpwood and 11.30 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 29.26 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 36 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 28). This optimal management regime will generate the maximum SEV of -$248.55 (Table 36), with a NPW of -$245.31 per acre (Table 32). This financially optimal rotation would produce an estimated 3,372.86 cubic feet of pulpwood and 7.35 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 27.06 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 36 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 28). This optimal management regime will generate the maximum SEV of -$304.22 (Table 36), with a NPW of -$303.22 per acre (Table 32). This financially optimal rotation would produce an estimated 3,372.86 cubic feet of pulpwood and 7.35 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 27.06 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 28). This optimal management regime will generate the maximum SEV of -$330.48 (Table 36), with a NPW of -$330.02 per acre (Table 32). This financially optimal rotation would produce an estimated 3,302.61 cubic feet of pulpwood and 7.23 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 26.57 net tons of carbon per acre during one rotation (Table 24).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 28). This optimal management regime will generate the maximum SEV of -$345.62 (Table 36), with a NPW of -$345.54 per acre (Table 32). This financially optimal rotation would produce an estimated 3,302.61 cubic feet of pulpwood and 7.23 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 26.57 net tons of carbon per acre during one rotation (Table 24).

<u>Lake States-Northern red oak - Timber Only Rotations (C = $37/ton)</u>

Northern red oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 77 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 86 (Table 29). This optimal management regime will generate the maximum SEV of $997.25 (Table 37), with a NPW of $880.88 per acre (Table 33). This means that $997.25 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $880.88 per acre for managing one rotation, or $997.25 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would

produce an estimated 2,628.86 cubic feet of pulpwood and 13.53 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 24.76 net tons of carbon per acre during one rotation (Table 25). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 55 and 77 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 29). This optimal management regime will generate the maximum SEV of $131.20 (Table 37), with a NPW of $129.50 per acre (Table 33). This financially optimal rotation would produce an estimated 2,937.23 cubic feet of pulpwood and 13.21 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 25.46 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 29). This optimal management regime will generate the maximum SEV of -$83.30 (Table 37), with a NPW of -$83.04 per acre (Table 33). This financially optimal rotation would produce an estimated 3,216.74 cubic feet of pulpwood and 8.76 MBF of sawlogs

per acre from the thinning and final harvest (Table 41), and sequester 22.59 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 29). This optimal management regime will generate the maximum SEV of -$179.67 (Table 37), with a NPW of -$179.58 per acre (Table 33). This financially optimal rotation would produce an estimated 3,216.74 cubic feet of pulpwood and 8.76 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 22.59 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 63 and 74 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 29). This optimal management regime will generate the maximum SEV of -$235.31 (Table 37), with a NPW of -$235.29 per acre (Table 33). This financially optimal rotation would produce an estimated 3,268.97 cubic feet of pulpwood and 8.92 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 22.97 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 63 and 74 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 29). This optimal management regime will generate the maximum SEV of -$271.21 (Table 37), with a NPW of -$271.21 per acre (Table 33). This financially optimal rotation would produce an estimated 3,268.97 cubic feet of pulpwood and 8.92 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 22.97 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 70 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 29). This optimal management regime will generate the maximum SEV of $1,381.50 (Table 37), with a NPW of $1,231.81 per acre (Table 33). This financially optimal rotation would produce an estimated 2,970.48 cubic feet of pulpwood and 18.93 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 30.35 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 70 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 29). This optimal management regime will generate the maximum SEV of $258.70 (Table 37), with a NPW of $252.95 per acre (Table 33). This financially optimal rotation would produce an estimated 3,068.40 cubic feet of pulpwood and 13.31 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 27.39 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 55 and 72 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 29). This optimal management regime will generate the maximum SEV of -$9.44 (Table 37), with a NPW of -$9.41 per acre (Table 33). This financially optimal rotation would produce an estimated 3,498.93 cubic feet of pulpwood and 12.47 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 27.98 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 69 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table

29). This optimal management regime will generate the maximum SEV of -$127.47 (Table 37), with a NPW of -$127.37 per acre (Table 33). This financially optimal rotation would produce an estimated 3,682.02 cubic feet of pulpwood and 8.78 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 25.51 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 29). This optimal management regime will generate the maximum SEV of -$195.51 (Table 37), with a NPW of -$195.49 per acre (Table 33). This financially optimal rotation would produce an estimated 3,724.33 cubic feet of pulpwood and 8.84 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 25.77 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 29). This optimal management regime will generate the maximum SEV of -$239.66 (Table 37), with a NPW of -$239.65 per acre (Table 33). This financially optimal rotation would produce an estimated 3,724.33 cubic feet of pulpwood and 8.84 MBF of

sawlogs per acre from the thinning and final harvest (Table 41), and sequester 25.77 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 64 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of $1,706.07 (Table 37), with a NPW of $1,525.72 per acre (Table 33). This financially optimal rotation would produce an estimated 2,978.13 cubic feet of pulpwood and 23.02 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 34.13 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 64 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 29). This optimal management regime will generate the maximum SEV of $391.55 (Table 37), with a NPW of $383.65 per acre (Table 33). This financially optimal rotation would produce an estimated 3,118.70 cubic feet of pulpwood and 17.19 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 31.92 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 67 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 73 (Table 29). This optimal management regime will generate the maximum SEV of $72.28 (Table 27), with a NPW of $71.93 per acre (Table 33). This financially optimal rotation would produce an estimated 3,744.89 cubic feet of pulpwood and 11.94 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 30.48 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 67 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 73 (Table 29). This optimal management regime will generate the maximum SEV of -$69.50 (Table 37), with a NPW of -$69.44 per acre (Table 33). This financially optimal rotation would produce an estimated 3,744.89 cubic feet of pulpwood and 11.94 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 30.48 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 55 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 29). This optimal management regime will generate the maximum SEV of -$151.37 (Table 37), with a NPW of -$151.33 per acre (Table 33). This financially optimal rotation would produce an estimated 3,601.35 cubic feet of pulpwood and 9.23 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 28.24 net tons of carbon per acre during one rotation (Table 25).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 55 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 29). This optimal management regime will generate the maximum SEV of -$204.71 (Table 37), with a NPW of -$204.70 per acre (Table 33). This financially optimal rotation would produce an estimated 3,601.35 cubic feet of pulpwood and 9.23 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 28.24 net tons of carbon per acre during one rotation (Table 25).

Lake States- Northern red oak - Timber Only Rotations (C = $50/ton)

Northern red oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 77 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 86 (Table 30). This optimal management regime will generate the maximum SEV of $1,280.34 (Table 38), with a NPW of $1,130.94 per acre (Table 34). This means that $1,280.34 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,130.94 per acre for managing one rotation, or $1,280.34 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,625.99 cubic feet of pulpwood and 13.53 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 24.76 net tons of carbon per acre during one rotation (Table 26). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 79 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table

30). This optimal management regime will generate the maximum SEV of $296.90 (Table 38), with a NPW of $293.40 per acre (Table 34). This financially optimal rotation would produce an estimated 2,867.45 cubic feet of pulpwood and 13.87 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 25.60 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 63 and 74 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 30). This optimal management regime will generate the maximum SEV of $26.30 (Table 38), with a NPW of $26.22 per acre (Table 34). This financially optimal rotation would produce an estimated 3,268.97 cubic feet of pulpwood and 8.92 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 22.97 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 63 and 74 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 30). This optimal management regime will generate the maximum SEV of -$102.08 (Table 38), with a NPW of -$102.04 per acre (Table 34). This financially optimal rotation would produce an estimated 3,268.97 cubic feet of pulpwood and 8.92 MBF of

sawlogs per acre from the thinning and final harvest (Table 42), and sequester 22.97 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 63 and 74 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 30). This optimal management regime will generate the maximum SEV of -$177.47 (Table 38), with a NPW of -$177.46 per acre (Table 34). This financially optimal rotation would produce an estimated 3,268.97 cubic feet of pulpwood and 8.82 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 22.97 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 65 and 74 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 30). This optimal management regime will generate the maximum SEV of -$226.35 (Table 38), with a NPW of -$226.35 per acre (Table 34). This financially optimal rotation would produce an estimated 3,215.79 cubic feet of pulpwood and 8.73 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 22.56 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 70 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 30). This optimal management regime will generate the maximum SEV of $1,722.13 (Table 38), with a NPW of $1,535.53 per acre (Table 34). This financially optimal rotation would produce an estimated 2,970.48 cubic feet of pulpwood and 18.93 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 30.35 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 30). This optimal management regime will generate the maximum SEV of $453.03 (Table 38), with a NPW of $444.73 per acre (Table 34). This financially optimal rotation would produce an estimated 3,278.60 cubic feet of pulpwood and 13.60 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 28.20 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 74 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 30). This optimal management regime will generate the maximum SEV of $124.11 (Table 38), with a NPW of $123.81 per acre (Table 34). This financially optimal rotation would produce an estimated 3,430.62 cubic feet of pulpwood and 13.25 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 28.19 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 59 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 30). This optimal management regime will generate the maximum SEV of -$31.90 (Table 38), with a NPW of -$31.88 per acre (Table 34). This financially optimal rotation would produce an estimated 3,602.02 cubic feet of pulpwood and 9.34 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 25.39 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table

30). This optimal management regime will generate the maximum SEV of -$123.77 (Table 38), with a NPW of -$123.75 per acre (Table 34). This financially optimal rotation would produce an estimated 3,724.33 cubic feet of pulpwood and 8.84 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 25.77 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 30). This optimal management regime will generate the maximum SEV of -$183.72 (Table 38), with a NPW of -$182.72 per acre (Table 34). This financially optimal rotation would produce an estimated 3,724.33 cubic feet of pulpwood and 8.84 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 25.77 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 69 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $2,101.44 (Table 38), with a NPW of $1,879.29 per acre (Table 34). This financially optimal rotation would produce an estimated 2,978.13 cubic feet of pulpwood and 23.02 MBF of

sawlogs per acre from the thinning and final harvest (Table 42), and sequester 34.13 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 68 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 30). This optimal management regime will generate the maximum SEV of $624.88 (Table 38), with a NPW of $613.44 per acre (Table 34). This financially optimal rotation would produce an estimated 3,118.70 cubic feet of pulpwood and 17.14 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 33.49 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 55 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 30). This optimal management regime will generate the maximum SEV of $232.07 (Table 38), with a NPW of $231.19 per acre (Table 34). This financially optimal rotation would produce an estimated 3,744.89 cubic feet of pulpwood and 12.93 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 30.32 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 55 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 30). This optimal management regime will generate the maximum SEV of $45.91 (Table 38), with a NPW of $45.88 per acre (Table 34). This financially optimal rotation would produce an estimated 3,744.89 cubic feet of pulpwood and 12.93 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 30.32 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 55 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 30). This optimal management regime will generate the maximum SEV of -$64.27 (Table 38), with a NPW of -$64.25 per acre (Table 34). This financially optimal rotation would produce an estimated 3,601.35 cubic feet of pulpwood and 9.23 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 28.24 net tons of carbon per acre during one rotation (Table 26).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 55 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 30). This optimal management regime will generate the maximum SEV of -$136.53 (Table 38), with a NPW of -$136.53 per acre (Table 34). This financially optimal rotation would produce an estimated 3,601.35 cubic feet of pulpwood and 9.23 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 28.24 net tons of carbon per acre during one rotation (Table 26).

Species ___Northern red oak__________ Region ______Northeast_________________

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 8.25, 10.50, and 12.35 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 20 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183628319 and 0.553097345, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Pastor et al. (1984) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$\mathrm{Ln}(Y) = 4.9967+2.3944*\ln(D)$$

where:

Y = dry-weight (g.) aboveground with leaves

D = diameter at breast height (cm.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisors 2005). The price of sawtimber was assumed to be $330/mbf (International 1/4) (WVU Division of Forestry, http://ahc.caf.wvu.edu/., University of Maryland, http://www.naturalresources.umd.edu/Stumpage_Prices.cfm., Universities of Connecticut and Massachusetts, http://forest.fnr.umass.edu/snestumpage.htm., University of Vermont Extension, http://stumpage.uvm.edu/stumpage.php., Maine Department of Conservation, http://www.state.me.us/doc/mfs/pubs.htm. February 3, 2006) and pulpwood price was assumed to be $8.66/cord (WVU Division of Forestry, http://ahc.caf.wvu.edu/., University of Maryland, http://www.naturalresources.umd.edu/Stumpage_Prices.cfm., Universities of Connecticut and Massachusetts, http://forest.fnr.umass.edu/snestumpage.htm., University of Vermont Extension, http://stumpage.uvm.edu/stumpage.php., Maine Department of Conservation, http://www.state.me.us/doc/mfs/pubs.htm. February 3, 2006). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of northern red oak plantations in the Northeast.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$152.60	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]The seedling cost was estimated based on the seedling prices from Maryland DNR Forest Service (http://www.dnr.state.md.us/forests/nursery/deciduous.html. Feb.8,2006), Croshaw Nursery (http://www.croshawnursery.com/PriceList.html. Feb.8, 2006) and New Hampshire State Forest Nursery (http://www.nh.gov/dred/nhnursery/seedlings.htm. Feb.8,2006).

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Table 45. Total tons of carbon sequestered per acre for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	39.40	36.20	34.12	30.21	30.21	30.21
80	37.75	37.38	35.43	35.43	32.60	32.60
90	42.01	42.01	37.24	37.80	25.90	25.90

[1]Base age 50.

Table 46. Total tons of carbon sequestered per acre for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	39.40	36.20	36.20	34.12	30.21	30.21
80	37.75	37.38	35.43	35.43	35.43	35.43
90	42.01	42.01	37.24	34.34	33.08	31.35

[1]Base age 50.

Table 47. Total tons of carbon sequestered per acre for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	39.40	36.20	33.92	33.92	33.92	33.25
80	37.75	37.75	37.75	36.02	36.02	35.13
90	42.01	42.01	46.73	46.25	37.93	37.93

[1]Base age 50.

Table 48. Total tons of carbon sequestered per acre for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	39.40	36.20	33.92	33.92	33.92	33.25
80	37.75	37.75	37.75	36.02	34.09	34.09
90	42.01	40.61	46.25	46.25	44.05	43.27

[1]Base age 50.

Table 49. Financially optimal thinning and final harvest schedules which maximize soil expectation value for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	49-68-**90**[2] (30%)[3]	<49-56-**79**>[4](30%)	<40-47-**75**> (30%)	<40-47-**64**> (30%)	<40-47-**64**> (30%)	<40-47-**64**> (30%)
80	42-**90** (20%)	<32-37-**89**> (30%)	<30-39-**76**> (30%)	<30-39-**76**> (30%)	<30-36-**74**> (30%)	<30-36-**74**> (30%)
90	27-**87** (30%)	<27-**87**> (30%)	<27-**76**> (30%)	<26-**51**> (30%)	<26-**46**> (30%)	<26-**46**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 50. Financially optimal thinning and final harvest schedules which maximize soil expectation value for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	49-68-**90**[2] (30%)[3]	<49-56-**79>**[4](30%)	<49-56-**79>** (30%)	<40-47-**75>** (30%)	<40-47-**64>** (30%)	<40-47-**64>** (30%)
80	42-**90** (20%)	<32-37-**89>** (30%)	<30-39-**76>** (30%)	<30-39-**76>** (30%)	<30-39-**76>** (30%)	<30-39-**76>** (30%)
90	27-**87** (30%)	27-**87** (30%)	<27-**76>** (30%)	<32-**54>** (25%)	<28-**52>** (25%)	<28-**47>** (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 51. Financially optimal thinning and final harvest schedules which maximize soil expectation value for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	49-68-**90**[2] (30%)[3]	49-56-**79** (30%)	71-**76** (30%)	71-**76** (30%)	<71-**76**>[4] (30%)	<71-**76**> (20%)
80	42-**90** (20%)	42-**90** (20%)	42-**90** (20%)	75-**90** (20%)	<75-**90**> (20%)	<79-**90**> (20%)
90	27-**87** (30%)	27-**87** (30%)	32-**79** (25%)	64-**81** (25%)	56-**61** (25%)	<56-**61**> (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 52. Financially optimal thinning and final harvest schedules which maximize soil expectation value for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	49-68-**90**[2] (30%)[3]	49-56-**79** (30%)	71-**76** (30%)	71-**76** (30%)	71-**76** (30%)	<71-**76**>[4] (20%)
80	42-**90** (20%)	42-**90** (20%)	42-**90** (20%)	75-**90** (20%)	84-**90** (20%)	84-**90** (20%)
90	27-**87** (30%)	32-**90** (25%)	64-**81** (25%)	64-**81** (25%)	73-**81** (25%)	76-**81** (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 53. Net present worth of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$652.99	-$255.59	-$377.68	-$395.46	-$398.30	-$398.37
80	$1,044.58	-$228.24	-$368.75	-$392.90	-$397.12	-$397.64
90	$1,901.04	-$115.70	-$355.49	-$387.55	-$393.71	-$396.12

[1]Base age 50.

Table 54. Net present worth of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$948.40	-$55.54	-$231.41	-$282.48	-$307.09	-$323.15
80	$1,358.73	-$16.02	-$210.31	-$268.31	-$296.13	-$313.89
90	$2,241.69	$122.06	-$181.16	-$250.69	-$282.48	-$302.73

[1]Base age 50.

Table 55. Net present worth of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,746.02	$484.60	$170.32	$27.87	-$59.25	-$119.45
80	$2,206.95	$577.89	$221.70	$72.80	-$19.99	-$85.62
90	$3,161.46	$764.00	$301.96	$128.02	$24.31	-$48.00

[1]Base age 50.

Table 56. Net present worth of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$2,130.06	$744.66	$365.33	$177.69	$60.31	-$21.28
80	$2,615.35	$864.98	$434.16	$239.20	$113.55	$24.47
90	$3,604.32	$1,081.84	$537.67	$312.73	$173.17	$75.19

[1]Base age 50.

Table 57. Soil expectation value of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$730.17	-$260.85	-$379.23	-$396.27	-$398.49	-$398.41
80	$1,168.06	-$231.10	-$370.17	-$393.15	-$397.17	-$397.65
90	$2,145.26	-$117.30	-$356.85	-$390.30	-$395.27	-$396.68

[1]Base age 50.

Table 58. Soil expectation value of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,060.51	-$56.68	-$232.13	-$282.68	-$307.24	-$323.19
80	$1,519.35	-$16.22	-$211.11	-$268.48	-$296.16	-$313.90
90	$2,529.67	$123.75	-$181.16	-$252.03	-$283.03	-$303.10

[1]Base age 50.

Table 59. Soil expectation value of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,952.42	$494.58	$170.98	$27.89	-$59.26	-$119.45
80	$2,467.83	$584.79	$222.00	$72.82	-$19.99	-$85.62
90	$3,567.61	$774.58	$302.89	$128.07	$24.33	-$48.01

[1]Base age 50.

Table 60. Soil expectation value of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the northeast United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$2,381.85	$760.00	$366.73	$177.81	$60.32	-$21.28
80	$2,924.51	$875.30	$434.76	$239.24	$113.55	$24.47
90	$4,067.35	$1,094.76	$539.10	$312.85	$173.18	$75.19

[1]Base age 50.

Table 61. Volume removed from the financially optimal schedules for northern red oak plantations by soil productivity and real alternative rates of return in the northeast United States). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	49-68-**90**[3] (30%)[4]	747.68	0	837.72	0	2,002.98	7.44	3,588.38	7.44
	5.0%	49-56-**79** (30%)	747.68	0	613.61	0	1,906.26	6.26	3,267.55	6.26
	7.5%	40-47-**75** (30%)	659.91	0	558.05	0	2,703.97	4.87	3,921.96	4.87
	10.0%	40 47-**64** (30%)	659.91	0	558.05	0	1,933.56	2.20	3,151.55	2.20
	12.5%	40 47-**64** (30%)	659.91	0	558.05	0	1,933.56	2.20	3,151.55	2.20
	15.0%	40 47-**64** (30%)	659.91	0	558.05	0	1,933.56	2.20	3,151.55	2.20
80	2.5%	42-**90** (20%)	558.28	0	-[5]	-	2,756.84	10.44	3,315.12	10.44
	5.0%	32-37-**89** (30%)	627.03	0	594.28	0	1,881.70	10.02	3,103.01	10.02
	7.5%	30-39-**76** (30%)	612.38	0	642.04	0	2,280.40	6.29	3,534.89	6.29
	10.0%	30-39-**76** (30%)	612.38	0	642.04	0	2,280.40	6.29	3,534.89	6.29
	12.5%	30-36-**74** (30%)	612.38	0	600.05	0	2,298.08	4.21	3,510.51	4.21
	15.0%	30-36-**74** (30%)	612.38	0	600.05	0	2,298.08	4.21	3,510.51	4.21
90	2.5%	27-**87** (30%)	611.79	0	-	-	2,523.34	16.34	3,135.13	16.34
	5.0%	27-**87** (30%)	611.79	0	-	-	2,523.34	16.34	3,135.13	16.34
	7.5%	27-**76** (30%)	611.79	0	-	-	2,974.87	10.07	3,586.66	10.07
	10.0%	26-**51** (30%)	606.30	0	-	-	2,940.60	1.50	3,546.90	1.50
	12.5%	26-**46** (30%)	606.30	0	-	-	2,785.22	1.01	3,391.52	1.01
	15.0%	26-**46** (30%)	606.30	0	-	-	2,785.22	1.01	3,391.52	1.01

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 62. Volume removed from the financially optimal schedules for northern red oak plantations by soil productivity and real alternative rates of return in the northeast United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	49-68-**90**[3] (30%)[4]	747.68	0	837.72	0	2,002.98	7.44	3,588.38	7.44
	5.0%	49-56-**79** (30%)	747.68	0	613.61	0	1,906.26	6.26	3,267.55	6.26
	7.5%	49-56-**79** (30%)	747.68	0	613.61	0	1,906.26	6.26	3,267.55	6.26
	10.0%	40-47-**75** (30%)	659.91	0	558.05	0	2,073.97	4.87	3,291.93	4.87
	12.5%	40-47-**64** (30%)	659.91	0	558.05	0	1,933.56	2.20	3,151.52	2.20
	15.0%	40-47-**64** (30%)	659.91	0	558.05	0	1,933.56	2.20	3,151.52	2.20
80	2.5%	42-**90** (20%)	558.28	0	-[5]	-	2,756.84	10.44	3,315.12	10.44
	5.0%	32-37-**89** (30%)	627.03	0	594.28	0	1,881.70	10.02	3,103.01	10.02
	7.5%	30-39-**76** (30%)	612.38	0	642.04	0	2,280.47	6.29	3,534.89	6.29
	10.0%	30-39-**76** (30%)	612.38	0	642.04	0	2,280.47	6.29	3,534.89	6.29
	12.5%	30-39-**76** (30%)	612.38	0	642.04	0	2,280.47	6.29	3,534.89	6.29
	15.0%	30-39-**76** (30%)	612.38	0	642.04	0	2,280.47	6.29	3,534.89	6.29
90	2.5%	27-**87** (30%)	611.79	0	-	-	2,523.34	16.34	3,135.13	16.34
	5.0%	27-**87** (30%)	611.79	0	-	-	2,523.34	16.34	3,135.13	16.34
	7.5%	27-**76** (30%)	611.79	0	-	-	2,974.87	10.07	3,586.66	10.07
	10.0%	32-**54** (25%)	651.10	0	-	-	2,989.46	1.91	3,640.56	1.91
	12.5%	28-**52** (25%)	609.70	0	-	-	2,990.85	1.48	3,600.55	1.48
	15.0%	28-**47** (25%)	609.70	0	-	-	2,844.24	1.00	3,453.94	1.00

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 63. Volume removed from the financially optimal schedules for northern red oak plantations by soil productivity and real alternative rates of return in the northeast United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	49-68-**90**[3] (30%)[4]	747.68	0	837.72	0	2,002.98	7.44	3,588.38	7.44
	5.0%	49-56-**79** (30%)	747.68	0	613.61	0	1,906.26	6.26	3,267.55	6.26
	7.5%	71-**76** (30%)	1,148.78	0	-[5]	-	2,293.83	4.57	3,442.61	4.57
	10.0%	71-**76** (30%)	1,148.78	0	-	-	2,293.83	4.57	3,442.61	4.57
	12.5%	71-**76** (30%)	1,148.78	0	-	-	2,293.83	4.57	3,442.61	4.57
	15.0%	71-**76** (20%)	765.85	0	-	-	2,601.86	4.50	3,367.71	4.50
80	2.5%	42-**90** (20%)	558.28	0	-	-	2,756.84	10.44	3,315.12	10.44
	5.0%	42-**90** (20%)	558.28	0	-	-	2,756.84	10.44	3,315.12	10.44
	7.5%	42-**90** (20%)	558.28	0	-	-	2,756.84	10.44	3,315.12	10.44
	10.0%	75-**90** (20%)	882.36	0	-	-	2,950.73	5.42	3,833.09	5.42
	12.5%	75-**90** (20%)	882.36	0	-	-	2,950.73	5.42	3,833.09	5.42
	15.0%	79-**90** (20%)	883.24	0	-	-	2,862.96	5.26	3,746.20	5.26
90	2.5%	27-**87** (30%)	611.79	0	-	-	2,523.34	16.34	3,135.13	16.34
	5.0%	27-**87** (30%)	611.79	0	-	-	2,523.34	16.34	3,135.13	16.34
	7.5%	32-**79** (25%)	651.10	0	-	-	3,140.62	10.31	3,791.72	10.31
	10.0%	67-**81** (25%)	1,101.93	0	-	-	2,948.65	8.41	4,050.58	8.41
	12.5%	56-**61** (25%)	1,011.05	0	-	-	2,972.54	2.15	3,983.59	2.15
	15.0%	56-**61** (25%)	1,011.05	0	-	-	2,972.54	2.15	3,983.59	2.15

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 64. Volume removed from the financially optimal schedules for northern red oak plantations by soil productivity and real alternative rates of return in the northeast United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	49-68-**90**[3] (30%)[4]	747.68	0	837.72	0	2,002.98	7.44	3,588.38	7.44
	5.0%	49-56-**79** (30%)	747.68	0	613.61	0	1,906.26	6.26	3,267.55	6.26
	7.5%	71-**76** (30%)	1,148.78	0	-[5]	-	2,293.83	4.57	3,442.61	4.57
	10.0%	71-**76** (30%)	1,148.78	0	-	-	2,293.83	4.57	3,442.61	4.57
	12.5%	71-**76** (30%)	1,148.78	0	-	-	2,293.83	4.57	3,442.61	4.57
	15.0%	71-**76** (20%)	765.85	0	-	-	2,601.86	4.50	3,367.71	4.50
80	2.5%	42-**90** (20%)	558.28	0	-	-	2,756.84	10.44	3,315.12	10.44
	5.0%	42-**90** (20%)	558.28	0	-	-	2,756.84	10.44	3,315.12	10.44
	7.5%	42-**90** (20%)	558.28	0	-	-	2,756.84	10.44	3,315.12	10.44
	10.0%	75-**90** (20%)	882.36	0	-	-	2,950.73	5.42	3,833.09	5.42
	12.5%	84-**90** (20%)	884.62	0	-	-	2,753.60	5.06	3,638.22	5.06
	15.0%	84-**90** (20%)	884.62	0	-	-	2,753.60	5.06	3,638.22	5.06
90	2.5%	27-**87** (30%)	611.79	0	-	-	2,523.34	16.34	3,135.13	16.34
	5.0%	32-**90** (25%)	651.10	0	-	-	2,537.19	16.31	3,188.29	16.31
	7.5%	64-**81** (25%)	1,101.93	0	-	-	2,948.65	8.41	4,050.58	8.41
	10.0%	64-**81** (25%)	1,101.93	0	-	-	2,948.65	8.41	4,050.58	8.41
	12.5%	73-**81** (25%)	1,117.35	0	-	-	2,725.10	8.01	3,842.45	8.01
	15.0%	73-**81** (25%)	1,201.54	0	-	-	2,651.29	7.87	3,852.83	7.87

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 65. Financially optimal thinning and final harvest schedules for northern red oak plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	49-68-**90**[2] (30%)[3]	49-68-**90** (30%)	0%	49-68-**90** (30%)	0%	49-68-**90** (30%)	0%
	80	42-**90** (20%)	42-**90** (20%)	0%	42-**90** (20%)	0%	42-**90** (20%)	0%
	90	27-**87** (30%)	27-**87** (30%)	0%	27-**87** (30%)	0%	27-**87** (30%)	0%
5.00%	70	<49-56-**79**>[4](30%)	<49-56-**79**> (30%)	0%	49-56-**79** (30%)	0%	49-56-**79** (30%)	0%
	80	<32-37-**89**> (30%)	<32-37-**89**> (30%)	0%	42-**90** (20%)	1%	42-**90** (20%)	1%
	90	<27-**87**> (30%)	27-**87** (30%)	0%	27-**87** (30%)	0%	32-**90** (25%)	3%
7.50%	70	<40-47-**75**> (30%)	<49-56-**79**> (30%)	5%	71-**76** (30%)	1%	71-**76** (30%)	1%
	80	<30-39-**76**> (30%)	<30-39-**76**> (30%)	0%	42-**90** (20%)	18%	42-**90** (20%)	18%
	90	<27-**76**> (30%)	<27-**76**> (30%)	0%	32-**79** (25%)	4%	64-**81** (25%)	7%
10.00%	70	<40-47-**64**> (30%)	<40-47-**75**> (30%)	17%	71-**76** (30%)	19%	71-**76** (30%)	19%
	80	<30-39-**76**> (30%)	<30-39-**76**> (30%)	0%	75-**90** (20%)	18%	75-**90** (20%)	18%
	90	<26-**51**> (30%)	<32-**54**> (25%)	6%	64-**81** (25%)	59%	64-**81** (25%)	59%
12.50%	70	<40-47-**64**> (30%)	<40-47-**64**> (30%)	0%	<71-**76**> (30%)	19%	71-**76** (30%)	19%
	80	<30-36-**74**> (30%)	<30-39-**76**> (30%)	3%	<75-**90**> (20%)	22%	84-**90** (20%)	22%
	90	<26-**46**> (30%)	<28-**52**> (25%)	13%	56-**61** (25%)	33%	73-**81** (25%)	76%
15.00%	70	<40-47-**64**> (30%)	<40-47-**64**> (30%)	0%	<71-**76**> (20%)	19%	<71-**76**> (20%)	19%
	80	<30-36-**74**> (30%)	<30-39-**76**> (30%)	3%	<79-**90**> (20%)	22%	84-**90** (20%)	22%
	90	<26-**46**> (30%)	<28-**47**> (25%)	2%	<56-**61**> (25%)	33%	76-**81** (25%)	76%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3]Number in parentheses indicates the percentage of basal area removed during thinning

[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 66. The soil expectation value ($/acre) of the financially optimal rotations for northern red oak plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	730.17	1,060.51	45%	1,952.42	167%	2,381.85	226%
	80	1,168.06	1,519.35	30%	2,467.83	111%	2,924.51	150%
	90	2,145.26	2,529.67	18%	3,567.61	66%	4,067.35	90%
5.00%	70	-260.85	-56.68		494.58		760.00	
	80	-231.10	-16.22		584.79		875.30	
	90	-117.30	123.75		774.58		1,094.76	
7.50%	70	-379.23	-232.13		170.98		366.73	
	80	-370.17	-211.11		222.00		434.76	
	90	-356.85	-181.16		302.89		539.10	
10.00%	70	-396.27	-282.68		27.89		177.81	
	80	-393.15	-268.48		72.82		239.24	
	90	-390.30	-252.03		128.07		312.85	
12.50%	70	-398.49	-307.24		-59.26		60.32	
	80	-397.17	-296.16		-19.99		113.55	
	90	-395.27	-283.03		24.33		173.18	
15.00%	70	-398.41	-323.19		-119.45		-21.28	
	80	-397.65	-313.90		-85.62		24.47	
	90	-396.68	-303.10		-48.01		75.19	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>Northeast- Northern red oak - Timber Only Rotations (C = $0/ton)</u>

Northern red oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 49 and 68 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 49). This optimal management regime will generate the maximum SEV of $730.17 (Table 57), with a NPW of $652.99 per acre (Table 53). This means that $730.17 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $652.99 per acre for managing one rotation, or $730.17 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,588.38 cubic feet of pulpwood and 7.44 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 39.40 net tons of carbon per acre during one rotation (Table 45). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 49 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 49). This optimal management regime will generate the maximum SEV of -$260.85 (Table 57), with a NPW of -$255.59 per acre (Table 53). This financially optimal

rotation would produce an estimated 3,267.55 cubic feet of pulpwood and 6.26 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 36.20 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 49). This optimal management regime will generate the maximum SEV of -$379.23 (Table 57), with a NPW of -$377.68 per acre (Table 53). This financially optimal rotation would produce an estimated 3,921.96 cubic feet of pulpwood and 4.87 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 34.12 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 49). This optimal management regime will generate the maximum SEV of -$396.27 (Table 57), with a NPW of -$395.46 per acre (Table 53). This financially optimal rotation would produce an estimated 3,151.55 cubic feet of pulpwood and 2.20 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 30.21 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 49). This optimal management regime will generate the maximum SEV of -$398.49 (Table 57), with a NPW of -$398.30 per acre (Table 53). This financially optimal rotation would produce an estimated 3,151.55 cubic feet of pulpwood and 2.20 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 30.21 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 49). This optimal management regime will generate the maximum SEV of -$398.41 (Table 57), with a NPW of -$398.37 per acre (Table 53). This financially optimal rotation would produce an estimated 3,151.55 cubic feet of pulpwood and 2.20 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 30.21 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 42 (with 20 percent of

basal area removed) and a final harvest is conducted at stand age 90 (Table 49). This optimal management regime will generate the maximum SEV of $1,168.06 (Table 57), with a NPW of $1,044.58 per acre (Table 53). This financially optimal rotation would produce an estimated 3,315.12 cubic feet of pulpwood and 10.44 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 37.75 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 37 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 49). This optimal management regime will generate the maximum SEV of -$231.10 (Table 57), with a NPW of -$228.24 per acre (Table 53). This financially optimal rotation would produce an estimated 3,103.01 cubic feet of pulpwood and 10.02 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 37.38 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 49). This optimal management regime will generate the maximum SEV of -$370.17 (Table 57), with a NPW of -$368.75 per acre (Table 53). This financially optimal rotation would produce an estimated 3,534.89 cubic feet of pulpwood and 6.29 MBF of

sawlogs per acre from the thinning and final harvest (Table 61), and sequester 35.43 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 49). This optimal management regime will generate the maximum SEV of -$393.15 (Table 57), with a NPW of -$392.90 per acre (Table 53). This financially optimal rotation would produce an estimated 3,534.89 cubic feet of pulpwood and 6.29 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 35.43 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 36 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 49). This optimal management regime will generate the maximum SEV of -$397.17 (Table 57), with a NPW of -$397.12 per acre (Table 53). This financially optimal rotation would produce an estimated 3,510.51 cubic feet of pulpwood and 4.21 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 32.60 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 36 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 49). This optimal management regime will generate the maximum SEV of -$397.65 (Table 57), with a NPW of -$397.64 per acre (Table 53). This financially optimal rotation would produce an estimated 3,510.51 cubic feet of pulpwood and 4.21 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 32.60 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 49). This optimal management regime will generate the maximum SEV of $2,145.26 (Table 57), with a NPW of $1,901.04 per acre (Table 53). This financially optimal rotation would produce an estimated 3,135.13 cubic feet of pulpwood and 16.34 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 42.01 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 49). This

optimal management regime will generate the maximum SEV of -$117.30 (Table 57), with a NPW of -$115.70 per acre (Table 53). This financially optimal rotation would produce an estimated 3,135.13 cubic feet of pulpwood and 16.34 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 42.01 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 49). This optimal management regime will generate the maximum SEV of -$356.85 (Table 57), with a NPW of -$355.49 per acre (Table 53). This financially optimal rotation would produce an estimated 3,586.66 cubic feet of pulpwood and 10.0 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 37.24 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 49). This optimal management regime will generate the maximum SEV of -$390.30 (Table 57), with a NPW of -$387.55 per acre (Table 53). This financially optimal rotation would produce an estimated 3,546.90 cubic feet of pulpwood and 1.50 MBF of sawlogs per acre

from the thinning and final harvest (Table 61), and sequester 37.80 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 49). This optimal management regime will generate the maximum SEV of -$395.27 (Table 57), with a NPW of -$393.71 per acre (Table 53). This financially optimal rotation would produce an estimated 3,391.52 cubic feet of pulpwood and 1.01 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 25.90 net tons of carbon per acre during one rotation (Table 45).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 49). This optimal management regime will generate the maximum SEV of -$396.68 (Table 57), with a NPW of -$396.12 per acre (Table 53). This financially optimal rotation would produce an estimated 3,391.52 cubic feet of pulpwood and 1.01 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 25.90 net tons of carbon per acre during one rotation (Table 45).

Northeast- Northern red oak - Timber Only Rotations (C = $10/ton)

Northern red oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 49 and 68 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 50). This optimal management regime will generate the maximum SEV of $1,060.51 (Table 58), with a NPW of $948.40 per acre (Table 54). This means that $1,060.51 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $948.40 per acre for managing one rotation, or $1,060.51 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,588.38 cubic feet of pulpwood and 7.44 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 39.40 net tons of carbon per acre during one rotation (Table 46). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 49 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table

50). This optimal management regime will generate the maximum SEV of -$56.68 (Table 58), with a NPW of -$55.54 per acre (Table 54). This financially optimal rotation would produce an estimated 3,267.55 cubic feet of pulpwood and 6.26 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 36.20 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 49 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 50). This optimal management regime will generate the maximum SEV of -$232.13 (Table 58), with a NPW of -$331.41 per acre (Table 54). This financially optimal rotation would produce an estimated 3,267.55 cubic feet of pulpwood and 6.26 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 36.20 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 50). This optimal management regime will generate the maximum SEV of -$282.68 (Table 58), with a NPW of -$282.48 per acre (Table 54). This financially optimal rotation would produce an estimated 3,291.93 cubic feet of pulpwood and 4.87 MBF of

sawlogs per acre from the thinning and final harvest (Table 62), and sequester 34.12 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 50). This optimal management regime will generate the maximum SEV of -$307.24 (Table 58), with a NPW of -$307.09 per acre (Table 54). This financially optimal rotation would produce an estimated 3,151.52 cubic feet of pulpwood and 2.20 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 30.21 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 50). This optimal management regime will generate the maximum SEV of -$323.19 (Table 58), with a NPW of -$323.15 per acre (Table 54). This financially optimal rotation would produce an estimated 3,151.52 cubic feet of pulpwood and 2.20 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 30.21 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 42 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 50). This optimal management regime will generate the maximum SEV of $1,519.35 (Table 58), with a NPW of $1,358.73 per acre (Table 54). This financially optimal rotation would produce an estimated 3,315.12 cubic feet of pulpwood and 10.44 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 37.75 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 37 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 50). This optimal management regime will generate the maximum SEV of -$16.22 (Table 58), with a NPW of -$16.02 per acre (Table 54). This financially optimal rotation would produce an estimated 3,103.01 cubic feet of pulpwood and 10.02 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 37.38 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 50). This optimal management regime will generate the maximum SEV of -$211.11 (Table 58), with a NPW of -$210.31 per acre (Table 54). This financially optimal rotation would produce an estimated 3,534.89 cubic feet of pulpwood and 6.29 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 35.43 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 50). This optimal management regime will generate the maximum SEV of -$268.48 (Table 58), with a NPW of -$268.31 per acre (Table 54). This financially optimal rotation would produce an estimated 3,534.89 cubic feet of pulpwood and 6.29 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 35.43 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table

50). This optimal management regime will generate the maximum SEV of -$296.16 (Table 58), with a NPW of -$296.13 per acre (Table 54). This financially optimal rotation would produce an estimated 3,534.89 cubic feet of pulpwood and 6.29 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 35.43 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 50). This optimal management regime will generate the maximum SEV of -$313.90 (Table 58), with a NPW of -$313.89 per acre (Table 54). This financially optimal rotation would produce an estimated 3,534.89 cubic feet of pulpwood and 6.29 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 35.43 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 50). This optimal management regime will generate the maximum SEV of $2,529.67 (Table 58), with a NPW of $2,241.69 per acre (Table 54). This financially optimal rotation would produce an estimated 3,135.13 cubic feet of pulpwood and 16.34 MBF of sawlogs per

acre from the thinning and final harvest (Table 62), and sequester 42.01 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 50). This optimal management regime will generate the maximum SEV of $123.75 (Table 58), with a NPW of $122.06 per acre (Table 54). This financially optimal rotation would produce an estimated 3,135.13 cubic feet of pulpwood and 16.34 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 42.01 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 50). This optimal management regime will generate the maximum SEV of -$181.16 (Table 58), with a NPW of -$181.16 per acre (Table 54). This financially optimal rotation would produce an estimated 3,586.66 cubic feet of pulpwood and 10.07 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 37.24 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 50). This optimal management regime will generate the maximum SEV of -$252.03 (Table 58), with a NPW of -$250.69 per acre (Table 54). This financially optimal rotation would produce an estimated 3,640.56 cubic feet of pulpwood and 1.91 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 34.34 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 28 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 50). This optimal management regime will generate the maximum SEV of -$283.03 (Table 58), with a NPW of -$282.48 per acre (Table 54). This financially optimal rotation would produce an estimated 3,600.55 cubic feet of pulpwood and 1.48 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 33.08 net tons of carbon per acre during one rotation (Table 46).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 28 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 47 (Table 50). This optimal management regime will generate the maximum SEV of -$303.10 (Table 58), with a NPW of -$302.73 per acre (Table 54). This financially optimal rotation would produce an estimated 3,453.94 cubic feet of pulpwood and 1.00 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 31.35 net tons of carbon per acre during one rotation (Table 46).

<u>Northeast-Northern red oak - Timber Only Rotations (C = $37/ton)</u>

Northern red oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 49 and 68 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of $1,952.42 (Table 59), with a NPW of $1,746.02 per acre (Table 55). This means that $1,952.42 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,746.02 per acre for managing one rotation, or $1,952.42 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would

produce an estimated 3,588.38 cubic feet of pulpwood and 7.44 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 39.40 net tons of carbon per acre during one rotation (Table 47). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 49 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 51). This optimal management regime will generate the maximum SEV of $494.58 (Table 59), with a NPW of $484.60 per acre (Table 55). This financially optimal rotation would produce an estimated 3,267.55 cubic feet of pulpwood and 6.26 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 36.20 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 71 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 51). This optimal management regime will generate the maximum SEV of $170.98 (Table 59), with a NPW of $170.32 per acre (Table 55). This financially optimal rotation would produce an estimated 3,442.61 cubic feet of pulpwood and 4.57 MBF of sawlogs per acre

from the thinning and final harvest (Table 63), and sequester 33.92 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 71 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 51). This optimal management regime will generate the maximum SEV of $27.89 (Table 59), with a NPW of $27.87 per acre (Table 55). This financially optimal rotation would produce an estimated 3,442.61 cubic feet of pulpwood and 4.57 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 33.92 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 71 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 51). This optimal management regime will generate the maximum SEV of -$59.26 (Table 59), with a NPW of -$59.25 per acre (Table 55). This financially optimal rotation would produce an estimated 3,442.61 cubic feet of pulpwood and 4.57 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 33.92 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 71 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 51). This optimal management regime will generate the maximum SEV of -$119.45 (Table 59), with a NPW of -$119.45 per acre (Table 55). This financially optimal rotation would produce an estimated 3,442.61 cubic feet of pulpwood and 4.75 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 33.92 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 42 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of $2,467.93 (Table 59), with a NPW of $2,206.95 per acre (Table 55). This financially optimal rotation would produce an estimated 3,315.12 cubic feet of pulpwood and 10.44 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 37.75 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 42 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of $584.79 (Table 59), with a NPW of $577.89 per acre (Table 55). This financially optimal rotation would produce an estimated 3,315.12 cubic feet of pulpwood and 10.44 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 37.75 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 42 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of $222.00 (Table 59), with a NPW of $221.70 per acre (Table 55). This financially optimal rotation would produce an estimated 3,315.12 cubic feet of pulpwood and 10.44 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 37.75 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This

optimal management regime will generate the maximum SEV of $72.82 (Table 59), with a NPW of $72.80 per acre (Table 55). This financially optimal rotation would produce an estimated 3,833.09 cubic feet of pulpwood and 5.42 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 36.02 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of -$19.99 (Table 59), with a NPW of -$19.99 per acre (Table 55). This financially optimal rotation would produce an estimated 3,833.09 cubic feet of pulpwood and 5.42 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 36.02 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 79 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of -$85.62 (Table 59), with a NPW of -$85.62 per acre (Table 55). This financially optimal rotation would produce an estimated 3,746.20 cubic feet of pulpwood and 5.26 MBF of sawlogs per acre from the

thinning and final harvest (Table 63), and sequester 35.13 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 51). This optimal management regime will generate the maximum SEV of $3,567.61 (Table 59), with a NPW of $3,161.46 per acre (Table 55). This financially optimal rotation would produce an estimated 3,135.13 cubic feet of pulpwood and 16.34 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 42.01 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 51). This optimal management regime will generate the maximum SEV of $774.58 (Table 59), with a NPW of $764.00 per acre (Table 55). This financially optimal rotation would produce an estimated 3,135.13 cubic feet of pulpwood and 16.34 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 42.01 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 51). This optimal management regime will generate the maximum SEV of $302.89 (Table 59), with a NPW of $301.96 per acre (Table 55). This financially optimal rotation would produce an estimated 3,791.72 cubic feet of pulpwood and 10.31 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 46.73 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 64 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 51). This optimal management regime will generate the maximum SEV of $128.07 (Table 59), with a NPW of $128.02 per acre (Table 55). This financially optimal rotation would produce an estimated 4,050.58 cubic feet of pulpwood and 8.41 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 46.25 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 56 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 61 (Table 51). This optimal management regime will generate the maximum SEV of $24.33 (Table 59), with a NPW of $24.31 per acre (Table 55). This financially optimal rotation would produce an estimated 3,983.59 cubic feet of pulpwood and 2.15 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 37.93 net tons of carbon per acre during one rotation (Table 47).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 56 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 61 (Table 51). This optimal management regime will generate the maximum SEV of -$48.01 (Table 59), with a NPW of -$48.00 per acre (Table 55). This financially optimal rotation would produce an estimated 3,983.59 cubic feet of pulpwood and 2.15 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 37.93 net tons of carbon per acre during one rotation (Table 47).

<u>Northeast- Northern red oak - Timber Only Rotations (C = $50/ton)</u>

Northern red oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 49 and 68 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $2,381.85 (Table 60), with a NPW of $2,130.06 per acre (Table 56). This means that $2,381.85 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,130.06 per acre for managing one rotation, or $2,381.85 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,588.38 cubic feet of pulpwood and 7.44 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 39.40 net tons of carbon per acre during one rotation (Table 48). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 49 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table

52). This optimal management regime will generate the maximum SEV of $760.00 (Table 60), with a NPW of $744.66 per acre (Table 56). This financially optimal rotation would produce an estimated 3,267.55 cubic feet of pulpwood and 6.26 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 36.20 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 71 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 52). This optimal management regime will generate the maximum SEV of $366.73 (Table 60), with a NPW of $365.33 per acre (Table 56). This financially optimal rotation would produce an estimated 3,442.61 cubic feet of pulpwood and 4.57 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 33.92 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 71 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 52). This optimal management regime will generate the maximum SEV of $177.81 (Table 60), with a NPW of $177.69 per acre (Table 56). This financially optimal rotation would produce an estimated 3,442.61 cubic feet of pulpwood and 4.57 MBF of sawlogs per acre

from the thinning and final harvest (Table 64), and sequester 33.92 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 71 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 52). This optimal management regime will generate the maximum SEV of $60.32 (Table 60), with a NPW of $60.31 per acre (Table 56). This financially optimal rotation would produce an estimated 3,442.61 cubic feet of pulpwood and 4.57 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 33.92 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 71 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 52). This optimal management regime will generate the maximum SEV of -$21.28 (Table 60), with a NPW of -$21.28 per acre (Table 56). This financially optimal rotation would produce an estimated 3,367.71 cubic feet of pulpwood and 4.50 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 33.25 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 42 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $2,924.51 (Table 60), with a NPW of $2,615.35 per acre (Table 56). This financially optimal rotation would produce an estimated 3,315.12 cubic feet of pulpwood and 10.44 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 37.75 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 42 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $875.30 (Table 60), with a NPW of $864.98 per acre (Table 56). This financially optimal rotation would produce an estimated 3,315.12 cubic feet of pulpwood and 10.44 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 37.75 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 42 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $434.76 (Table 60), with a NPW of $434.16 per acre (Table 56). This financially optimal rotation would produce an estimated 3,315.12 cubic feet of pulpwood and 10.44 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 37.75 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $239.24 (Table 60), with a NPW of $239.20 per acre (Table 56). This financially optimal rotation would produce an estimated 3,833.09 cubic feet of pulpwood and 5.42 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 36.02 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 84 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This

optimal management regime will generate the maximum SEV of $113.55 (Table 60), with a NPW of $113.55 per acre (Table 56). This financially optimal rotation would produce an estimated 3,638.22 cubic feet of pulpwood and 5.06 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 34.09 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 84 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $24.47 (Table 60), with a NPW of $24.47 per acre (Table 56). This financially optimal rotation would produce an estimated 3,638.22 cubic feet of pulpwood and 5.06 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 34.09 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 52). This optimal management regime will generate the maximum SEV of $4,067.35 (Table 60), with a NPW of $3,604.32 per acre (Table 56). This financially optimal rotation would produce an estimated 3,135.13 cubic feet of pulpwood and 16.34 MBF of sawlogs per

acre from the thinning and final harvest (Table 64), and sequester 42.01 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $1,094.76 (Table 60), with a NPW of $1,081.84 per acre (Table 56). This financially optimal rotation would produce an estimated 3,188.29 cubic feet of pulpwood and 16.31 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 40.61 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 64 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 52). This optimal management regime will generate the maximum SEV of $539.10 (Table 60), with a NPW of $537.67 per acre (Table 56). This financially optimal rotation would produce an estimated 4,050.58 cubic feet of pulpwood and 8.41 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 46.25 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 64 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 52). This optimal management regime will generate the maximum SEV of $312.85 (Table 60), with a NPW of $312.73 per acre (Table 56). This financially optimal rotation would produce an estimated 4,050.58 cubic feet of pulpwood and 8.41 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 46.25 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 52). This optimal management regime will generate the maximum SEV of $173.18 (Table 60), with a NPW of $173.17 per acre (Table 56). This financially optimal rotation would produce an estimated 3,842.45 cubic feet of pulpwood and 8.01 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 44.05 net tons of carbon per acre during one rotation (Table 48).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 76 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 52). This optimal management regime will generate the maximum SEV of $75.19 (Table 60), with a NPW of $75.19 per acre (Table 56). This financially optimal rotation would produce an estimated 3,852.83 cubic feet of pulpwood and 7.87 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 43.27 net tons of carbon per acre during one rotation (Table 48).

Species___Northern red oak__________ Region______South_________________

Site indices 90, 100 and 110 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 9-in. inside bark top diameter for trees with a minimum of 12 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 11-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 20 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a “thinning and final harvest” regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 25, 30 and 35% of basal area removal. Three thinning intensities were employed: 25, 30 and 35% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.245225694 and 0.434027778, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Clark and Schroeder (1986) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Yp = 0.15595(D^2H)^{0.93760}$$

$$Ys = 0.14071(D^2)^{0.95903}(H)^{0.93760}$$

where:

Yp = dry-weight (lbs.) of stemwood and bark of trees < 11.0 in. d.b.h

Ys = dry-weight (lbs.) of stemwood and bark of trees ≥ 11.0 in d.b.h

D = diameter at breast height (in.)

H = total height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 1.6% and 1.24% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $210/mbf (Scribner) (Timber Mart South, Inc. 2000-2005) and pulpwood price was assumed to be $16.44/cord (Timber Mart South, Inc. 2000-2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of northern red oak plantations in the South.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$60.00	Only once	Year 0	
Seedlings[b] (436 seedlings/ac)	$130.80	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).

[b]Data from Hans M. Williams, personal communication, Stephen F. Austin State University, December 19, 2006.

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Table 67. Total tons of carbon sequestered per acre for northern red oak plantations in the southern United States by site index and real alternative rates of return. (carbon value = $00/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	53.69	50.60	49.45	48.05	46.22	43.69
100	59.78	59.47	53.87	50.06	47.89	47.89
110	68.41	67.62	58.61	56.86	52.19	50.79

[1]Base age 50.

Table 68. Total tons of carbon sequestered per acre for northern red oak plantations in the southern United States by site index and real alternative rates of return. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	53.69	53.69	50.62	48.05	48.05	48.05
100	59.78	59.78	53.87	53.87	51.54	51.54
110	68.41	68.76	62.67	58.43	56.93	54.13

[1]Base age 50.

Table 69. Total tons of carbon sequestered per acre for northern red oak plantations in the southern United States by site index and real alternative rates of return. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	53.69	53.69	53.69	52.28	52.28	52.28
100	61.72	61.72	60.44	58.81	55.17	55.17
110	68.41	68.28	66.87	62.20	62.20	61.49

[1]Base age 50.

Table 70. Total tons of carbon sequestered per acre for northern red oak plantations in the southern United States by site index and real alternative rates of return. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	53.69	53.69	53.69	52.28	52.28	52.28
100	61.72	61.72	60.44	58.81	58.38	55.17
110	69.80	68.28	66.87	62.20	62.20	62.20

[1]Base age 50.

Table 71. Financially optimal thinning and final harvest schedules which maximize soil expectation value for northern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	50-**60**[2] (30%)[3]	31-**60** (35%)	<30-40-**58>**[4] (30%)	<33-44-**56**> (35%)	<32-38-**56**> (35%)	<30-36-**54**> (35%)
100	34-**60** (25%)	31-**60** (30%)	<34-40-**53**> (30%)	<28-33-**53**> (35%)	<28-34-**51**> (35%)	<28-34-**51**> (35%)
110	29-**60** (25%)	28-55-**60** (35%)	<27-35-**52**> (30%)	<27-35-**51**> (35%)	<25-30-**49**> (35%)	<25-30-**48**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 72. Financially optimal thinning and final harvest schedules which maximize soil expectation value for northern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	50-**60**[2] (30%)[3]	50-**60** (30%)	<35-44-**59**>[4] (25%)	<33-44-**56**> (35%)	<33-44-**56**> (35%)	<33-44-**56**> (35%)
100	34-**60** (25%)	34-**60** (25%)	<34-40-**53**> (30%)	<34-40-**53**> (30%)	<30-37-**52**> (30%)	<30-37-**52**> (30%)
110	29-55-**60** (25%)	33-55-**60** (30%)	29-**55** (25%)	<31-37-**51**> (30%)	<29-37-**50**> (30%)	<27-32-**49**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 73. Financially optimal thinning and final harvest schedules which maximize soil expectation value for northern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	50-**60**[2] (30%)[3]	50-**60** (30%)	50-**60** (30%)	<50-**59**>[4] (25%)	<50-**59**> (25%)	<50-**59**> (25%)
100	44-**60** (25%)	44-**60** (25%)	46-**59** (25%)	48-**57** (30%)	<47-**53**> (30%)	<47-**53**> (30%)
110	29-55-**60** (25%)	42-**58** (25%)	41-**57** (25%)	45-**53** (30%)	<45-**53**> (30%)	<44-**52**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 74. Financially optimal thinning and final harvest schedules which maximize soil expectation value for northern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	50-**60**[2] (30%)[3]	50-**60** (30%)	50-**60** (30%)	50-**59** (25%)	<50-**59**>[4] (25%)	<50-**59**> (25%)
100	44-**60** (25%)	44-**60** (25%)	46-**59** (25%)	48-**57** (30%)	47-**57** (25%)	<47-**53**> (30%)
110	44-**60** (25%)	42-**58** (25%)	41-**57** (25%)	45-**53** (30%)	45-**53** (30%)	<45-**53**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 75. Net present worth of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$1,773.30	$133.82	-$244.13	-$338.96	-$364.81	-$372.11
100	$2,408.65	$286.76	-$201.77	-$322.35	-$357.85	-$369.21
110	$2,823.08	$406.33	-$158.44	-$304.08	-$350.01	-$365.35

[1]Base age 50.

Table 76. Net present worth of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,095.02	$318.69	-$136.90	-$266.70	-$314.71	-$335.06
100	$2,776.54	$507.24	-$67.91	-$231.69	-$305.79	-$321.49
110	$3,247.84	$661.91	$0.63	-$197.02	-$272.49	-$306.75

[1]Base age 50.

Table 77. Net present worth of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,963.65	$830.81	$176.83	-$64.80	-$174.26	-$232.76
100	$3,783.73	$1,121.47	$314.89	$18.93	-$116.17	-$189.37
110	$4,394.67	$1,375.70	$454.77	$108.09	-$53.85	-$142.87

[1]Base age 50.

Table 78. Net present worth of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$3,381.88	$1,077.39	$328.67	$34.20	-$105.72	-$182.91
100	$4,276.90	$1,418.87	$501.79	$143.24	-$29.00	-$124.98
110	$4,953.97	$1,722.17	$676.20	$257.77	$53.41	-$62.76

[1]Base age 50.

Table 79. Soil expectation value of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,278.55	$141.01	-$247.61	-$340.45	-$365.25	-$372.28
100	$3,094.92	$302.17	-$205.92	-$324.24	-$358.63	-$369.47
110	$3,627.43	$428.16	-$161.94	-$307.04	-$350.98	-$365.74

[1]Base age 50.

Table 80. Soil expectation value of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,691.93	$335.81	-$138.71	-$267.87	-$314.55	-$335.17
100	$3,567.63	$534.49	-$69.31	-$233.05	-$306.63	-$321.69
110	$4,173.20	$697.47	$0.64	-$198.41	-$273.16	-$307.04

[1]Base age 50.

Table 81. Soil expectation value of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$3,008.05	$875.45	$179.00	-$65.01	-$174.40	-$232.81
100	$4,861.78	$1,181.73	$319.06	$19.00	-$116.37	-$189.47
110	$5,646.79	$1,457.64	$461.73	$108.73	-$53.94	-$142.96

[1]Base age 50.

Table 82. Soil expectation value of the financially optimal thinning and final harvest schedules for northern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$4,345.44	$1,135.28	$332.71	$34.33	-$105.81	-$182.95
100	$5,495.47	$1,495.10	$508.42	$143.81	-$29.03	-$125.05
110	$6,365.45	$1,824.74	$686.55	$259.28	$53.50	-$62.79

[1]Base age 50.

Table 83. Volume removed from the financially optimal schedules for northern red oak plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.50%	50-**60**[3] (30%)[4]	1,575.62	0	-[5]	-	1,309.19	18.04	2,884.81	18.04
	5.00%	31-**60** (35%)	656.01	0	-	-	1,627.71	18.26	2,283.72	18.26
	7.50%	30-40-**58** (30%)	552.28	0	993.19	0	913.00	16.12	2,458.47	16.12
	10.00%	33-44-**56** (35%)	872.34	0	1,167.70	0	923.89	13.74	2,963.93	13.74
	12.50%	32-38-**56** (35%)	791.54	0	852.50	0	1,124.80	13.28	2,768.84	13.28
	15.00%	30-36-**54** (35%)	552.28	0	777.43	0	1,476.12	10.94	2,805.83	10.94
100	2.50%	34-**60** (25%)	797.05	0	-	-	1,396.35	24.04	2,193.40	24.04
	5.00%	31-**60** (30%)	812.62	0	-	-	1,316.11	24.02	2,128.73	24.02
	7.50%	34-40-**53** (30%)	96.47	0	1,038.19	0	1,079.46	15.95	2,214.12	15.95
	10.00%	28-33-**53** (35%)	646.83	0	808.31	0	1,101.12	15.37	2,556.26	15.37
	12.50%	28-34-**51** (35%)	646.83	0	864.51	0	1,362.25	12.61	2,873.59	12.61
	15.00%	28-34-**51** (35%)	646.83	0	864.51	0	1,362.25	12.61	2,873.59	12.61
110	2.50%	29-**60** (25%)	718.56	0	-	-	948.47	23.22	1,667.03	23.22
	5.00%	28-55-**60** (35%)	956.89	0	725.07	6.80	753.84	20.06	2,435.80	26.86
	7.50%	27-35-**52** (30%)	760.96	0	1,010.74	0	1,140.44	18.70	2,912.14	18.70
	10.00%	27-35-**51** (35%)	894.33	0	1,108.62	0	1,054.89	16.95	3,057.84	16.95
	12.50%	25-30-**49** (35%)	648.68	0	816.53	0	1,509.61	14.07	2,974.82	14.07
	15.00%	25-30-**48** (35%)	648.69	0	816.53	0	1,661.04	12.57	3,126.26	12.57

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 84. Volume removed from the financially optimal schedules for loblolly pine plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	50-**60**[3] (30%)[4]	1,575.62	0	-[5]	-	1,309.19	18.04	2,884.81	18.04
	5.00%	50-**60** (30%)	1,575.62	0	-	-	1,309.19	18.04	2,884.81	18.04
	7.50%	35-44-**59** (25%)	686.96	0	875.46	0	1,101.68	16.90	2,664.10	16.90
	10.00%	33-44-**56** (35%)	872.34	0	1,167.70	0	923.89	13.74	2,963.93	13.74
	12.50%	33-44-**56** (35%)	872.34	0	1,167.70	0	923.89	13.74	2,963.93	13.74
	15.00%	33-44-**56** (35%)	872.34	0	1,167.70	0	923.89	13.74	2,963.93	13.74
80	2.50%	34-**60** (25%)	797.05	0	-	-	1,396.35	24.04	2,193.40	24.04
	5.00%	34-**60** (25%)	797.05	0	-	-	1,396.35	24.04	2,193.40	24.04
	7.50%	34-40-**53** (30%)	963.47	0	1,038.19	0	1,079.46	15.95	3,081.12	15.95
	10.00%	34-40-**53** (30%)	963.47	0	1,038.19	0	1,079.46	15.95	3,081.12	15.95
	12.50%	30-**52** (30%)	731.79	0	-	-	1,397.51	14.51	3,049.80	14.51
	15.00%	30-37-**52** (30%)	731.79	0	920.50	0	1,397.51	14.51	3,049.80	14.51
90	2.50%	29-55-**60** (25%)	718.56	0	782.52	4.2	948.47	23.22	2,449.55	27.42
	5.00%	33-55-**60** (30%)	1,096.73	0	668.74	0	817.30	21.36	2,582.77	21.36
	7.50%	29-**55** (25%)	718.56	0	-	-	1,173.84	23.36	1,892.40	23.36
	10.00%	31-37-**51** (30%)	981.25	0	1,072.91	0	1,119.37	17.40	3,173.53	17.40
	12.50%	29-37-**50** (30%)	868.13	0	1,090.71	0	1,352.42	16.00	3,311.26	16.00
	15.00%	27-32-**49** (30%)	760.96	0	830.49	0	1,743.04	14.29	3,334.49	14.29

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 85. Volume removed from the financially optimal schedules for loblolly pine plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	ARR	Schedule	1st thinning		2nd thinning		Final Harvest		Total Volume	
			Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	50-**60**[3] (30%)[4]	1,575.62	0	-[5]	-	1,309.19	18.04	2,884.81	18.04
	5.00%	50-**60** (30%)	1,575.62	0	-	-	1,309.19	18.04	2,884.81	18.04
	7.50%	50-**60** (30%)	1,575.62	0	-	-	1,309.19	18.04	2,884.81	18.04
	10.00%	50-**59** (25%)	1,305.41	0	-	-	1,591.86	17.23	2,897.27	17.23
	12.50%	50-**59** (25%)	1,305.41	0	-	-	1,591.86	17.23	2,897.27	17.23
	15.00%	50-**59** (25%)	1,305.41	0	-	-	1,591.86	17.23	2,897.27	17.23
80	2.50%	44-**60** (25%)	1,264.26	0	-	-	1,271.35	23.63	2,535.61	23.63
	5.00%	44-**60** (25%)	1,264.26	0	-	-	1,271.35	23.63	2,535.61	23.63
	7.50%	46-**59** (25%)	1,362.01	0	-	-	1,239.73	22.56	2,601.74	22.56
	10.00%	48-**57** (30%)	1,746.13	0	-	-	1,227.32	19.83	2,973.45	19.83
	12.50%	47-**53** (30%)	1,707.96	0	-	-	2,034.28	14.15	3,742.24	14.15
	15.00%	47-**53** (30%)	1,707.96	0	-	-	2,034.28	14.15	3,742.24	14.15
90	2.50%	29-55-**60** (25%)	718.56	0	782.52	0	948.47	23.22	2,449.55	23.22
	5.00%	42-**58** (25%)	1,378.55	0	-	-	1,309.55	25.94	2,688.10	25.94
	7.50%	41-**57** (25%)	1,324.49	0	-	-	1,347.83	25.11	2,672.32	25.11
	10.00%	45-**53** (30%)	1,847.29	0	-	-	1,406.21	19.74	3,253.50	19.74
	12.50%	45-**53** (30%)	1,847.29	0	-	-	1,406.21	19.74	3,253.50	19.74
	15.00%	44-**52** (30%)	1,802.08	0	-	-	1,780.14	17.77	3,582.22	17.77

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 86. Volume removed from the financially optimal schedules for loblolly pine plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	50-**60**[3] (30%)[4]	1,575.62	0	-[5]	-	1,309.19	18.04	2,884.81	18.04
	5.00%	50-**60** (30%)	1,575.62	0	-	-	1,309.19	18.04	2,884.81	18.04
	7.50%	50-**60** (30%)	1,575.62	0	-	-	1,309.19	18.04	2,884.81	18.04
	10.00%	50-**59** (25%)	1,305.41	0	-	-	1,591.86	17.23	2,897.27	17.23
	12.50%	50-**59** (25%)	1,305.41	0	-	-	1,591.86	17.23	2,897.27	17.23
	15.00%	50-**59** (25%)	1,305.41	0	-	-	1,591.86	17.23	2,897.27	17.23
80	2.50%	44-**60** (25%)	1,264.26	0	-	-	1,271.35	23.63	2,535.61	23.63
	5.00%	44-**60** (25%)	1,264.26	0	-	-	1,271.35	23.63	2,535.61	23.63
	7.50%	46-**59** (25%)	1,362.01	0	-	-	1,239.73	22.56	2,601.74	22.56
	10.00%	48-**57** (30%)	1,748.13	0	-	-	1,227.32	19.83	2,975.45	19.83
	12.50%	45-55-**60** (35%)	1,864.65	0	793.57	0	653.93	15.21	3,312.15	15.21
	15.00%	47-**53** (30%)	1,707.96	0	-	-	2,034.28	14.15	3,742.24	14.15
90	2.50%	44-**60** (25%)	1,493.81	0	-	-	1,243.18	26.85	2,736.99	26.85
	5.00%	42-**58** (25%)	1,378.55	0	-	-	1,309.55	25.94	2,688.10	25.94
	7.50%	41-54-**59** (25%)	1,324.49	0	677.59	0	908.84	21.14	2,910.92	21.14
	10.00%	45-**53** (30%)	1,847.29	0	-	-	1,406.21	19.74	3,253.50	19.74
	12.50%	45-**53** (30%)	1,847.29	0	-	-	1,406.21	19.74	3,253.50	19.74
	15.0%	45-**53** (30%)	1,847.29	0	-	-	1,406.21	19.74	3,253.50	19.74

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 87. Financially optimal thinning and final harvest schedules for northern red oak plantations managed exclusively for timber production (C=\$0/ton) or for timber production and carbon sequestration (C=\$10, 37 or 50/ton).

ARR	SI[1]	C=\$0/ton	C=\$10/ton	ΔR	C=\$37/ton	ΔR	C=\$50/ton	ΔR
2.50%	90	50-**60**[2] (30%)[3]	50-**60** (30%)	0%	50-**60** (30%)	0%	50-**60** (30%)	0%
	100	34-**60** (25%)	34-**60** (25%)	0%	44-**60** (25%)	0%	44-**60** (25%)	0%
	110	29-**60** (25%)	29-55-**60** (25%)	0%	29-55-**60** (25%)	0%	44-**60** (25%)	0%
5.00%	90	31-**60** (35%)	50-**60** (30%)	0%	50-**60** (30%)	0%	50-**60** (30%)	0%
	100	31-**60** (30%)	34-**60** (25%)	0%	44-**60** (25%)	0%	44-**60** (25%)	0%
	110	28-55-**60** (35%)	33-55-**60** (30%)	0%	42-**58** (25%)	-3%	42-**58** (25%)	0%
7.50%	90	<30-40-**58**>[4] (30%)	<35-44-**59**> (25%)	2%	50-**60** (30%)	3%	50-**60** (30%)	3%
	100	<34-40-**53**> (30%)	<34-40-**53**> (30%)	0%	46-**59** (25%)	11%	46-**59** (25%)	11%
	110	<27-35-**52**> (30%)	29-**55** (25%)	6%	41-**57** (25%)	10%	41-**57** (25%)	10%
10.00%	90	<33-44-**56**> (35%)	<33-44-**56**> (35%)	0%	<50-**59**> (25%)	5%	50-**59** (25%)	5%
	100	<28-33-**53**> (35%)	<34-40-**53**> (30%)	0%	48-**57** (30%)	8%	48-**57** (30%)	8%
	110	<27-35-**51**> (35%)	<31-37-**51**> (30%)	0%	45-**53** (30%)	4%	45-**53** (30%)	4%
12.50%	90	<32-38-**56**> (35%)	<33-44-**56**> (35%)	0%	<50-**59**> (25%)	5%	<50-**59**> (25%)	5%
	100	<28-34-**51**> (35%)	<30-37-**52**> (30%)	2%	<47-**53**> (30%)	4%	<47-**57**> (25%)	12%
	110	<25-30-**49**> (35%)	<29-37-**50**> (30%)	2%	<45-**53**> (30%)	8%	45-**53** (30%)	8%
15.00%	90	<30-36-**54**> (35%)	<33-44-**56**> (35%)	4%	<50-**59**> (25%)	9%	<50-**59**> (25%)	9%
	100	<28-34-**51**> (35%)	<30-37-**52**> (30%)	2%	<47-**53**> (30%)	4%	<47-**53**> (30%)	4%
	110	<25-30-**48**> (35%)	<27-32-**49**> (30%)	2%	<44-**52**> (30%)	8%	<45-**53**> (30%)	10%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3]Number in parentheses indicates the percentage of basal area removed during thinning

[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 88. The soil expectation value ($/acre) of the financially optimal rotations for northern red oak plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	90	2,278.55	2,691.93	18%	3,808.05	67%	4,345.44	91%
	100	3,094.92	3,567.63	15%	4,861.78	57%	5,495.47	78%
	110	3,627.43	4,173.20	15%	5,646.79	56%	6,365.45	75%
5.00%	90	141.01	335.81	138%	875.45	521%	1,135.28	705%
	100	302.17	534.49	77%	1,181.73	291%	1,495.10	395%
	110	428.16	697.47	63%	1,457.64	240%	1,824.74	326%
7.50%	90	-247.61	-138.71		179.00		332.71	
	100	-205.92	-69.31		319.06		508.42	
	110	-161.94	0.64		461.73		686.55	
10.00%	90	-340.45	-267.87		-65.01		34.33	
	100	-324.24	-233.05		19.00		143.81	
	110	-307.04	-198.41		108.73		259.28	
12.50%	90	-365.25	-314.55		-174.40		-105.81	
	100	-358.63	-306.63		-116.37		-29.03	
	110	-350.98	-273.16		-53.94		53.50	
15.00%	90	-372.28	-335.17		-232.81		-182.95	
	100	-369.47	-321.69		-189.47		-125.05	
	110	-365.74	-307.04		-142.96		-62.79	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>Southern- Northern red oak - Timber Only Rotations (C = $0/ton)</u>

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 50 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 71). This optimal management regime will generate the maximum SEV of $2,278.55 (Table 79), with a NPW of $1,773.30 per acre (Table 75). This means that $2,278.55 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,773.30 per acre for managing one rotation, or $2,278.55 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 2,884.81 cubic feet of pulpwood and 18.04 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 53.69 net tons of carbon per acre during one rotation (Table 67). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 31 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 71). This optimal management regime will generate the maximum SEV of $141.01 (Table 79), with a NPW of $133.82 per acre (Table 75). This financially optimal rotation could produce an

estimated 2,283.72 cubic feet of pulpwood and 16.26 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 50.60 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 30 and 40 (with 30 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 71). This optimal management regime will generate the maximum SEV of -$247.61 (Table 79), with a NPW of -$244.13 per acre (Table 75). This financially optimal rotation could produce an estimated 2,458.47 cubic feet of pulpwood and 16.12 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 49.45 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 33 and 44 (with 35 percent of basal area removed) and a final harvest at stand age 56 are conducted (Table 71). This optimal management regime will generate the maximum SEV of -$340.45 (Table 79), with a NPW of -$338.96 per acre (Table 75). This financially optimal rotation could produce an estimated 2,963.93 cubic feet of pulpwood and 13.74 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 48.05 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 32 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 56 are conducted (Table 71). This optimal management regime will generate the maximum SEV of -$365.25 (Table 79), with a NPW of -$364.81 per acre (Table 75). This financially optimal rotation could produce an estimated 2,768.84 cubic feet of pulpwood and 13.28 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 46.22 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 30 and 36 (with 35 percent of basal area removed) and a final harvest at stand age 54 are conducted (Table 71). This optimal management regime will generate the maximum SEV of -$372.28 (Table 79), with a NPW of -$372.11 per acre (Table 75). This financially optimal rotation could produce an estimated 2,805.83 cubic feet of pulpwood and 10.94 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 43.69 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 34 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 71). This optimal management regime will generate the maximum SEV of $3,094.92 (Table 79), with a NPW of $2,408.65 per acre (Table 75). This financially optimal rotation could produce an estimated 2,193.40 cubic feet of pulpwood and 24.04 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 59.78 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 31 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 71). This optimal management regime will generate the maximum SEV of $302.17 (Table 79), with a NPW of $286.76 per acre (Table 75). This financially optimal rotation could produce an estimated 2,128.73 cubic feet of pulpwood and 24.02 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 59.47 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 34 and 40 (with 30 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 71). This optimal management regime will generate the maximum SEV of -\$205.92 (Table 79), with a NPW of -\$201.77 per acre (Table 75). This financially optimal rotation could produce an estimated 2,214.12 cubic feet of pulpwood and 15.95 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 53.87 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = \$0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 28 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 71). This optimal management regime will generate the maximum SEV of -\$324.24 (Table 79), with a NPW of -\$322.35 per acre (Table 75). This financially optimal rotation could produce an estimated 2,556.26 cubic feet of pulpwood and 15.37 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 50.06 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = \$0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 28 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 51 are conducted (Table 71). This optimal management regime will generate the maximum SEV of -\$358.63 (Table 79), with a NPW of -\$357.87 per acre (Table 75). This financially optimal rotation could produce an estimated 2,873.59 cubic feet of pulpwood and 12.61 MBF of sawlogs per

acre from the thinning and final harvest (Table 83), and sequester 47.89 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 28 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 51 are conducted (Table 71). This optimal management regime will generate the maximum SEV of -$369.47 (Table 79), with a NPW of -$369.21 per acre (Table 75). This financially optimal rotation could produce an estimated 2,873.59 cubic feet of pulpwood and 12.61 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 47.89 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 29 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 71). This optimal management regime will generate the maximum SEV of $3,627.43 (Table 79), with a NPW of $2,823.08 per acre (Table 75). This financially optimal rotation could produce an estimated 1,667.03 cubic feet of pulpwood and 23.22 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 68.41 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 28 and 55 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 71). This optimal management regime will generate the maximum SEV of $428.16 (Table 79), with a NPW of $406.33 per acre (Table 75). This financially optimal rotation could produce an estimated 2,435.80 cubic feet of pulpwood and 26.84 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 67.62 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 27 and 35 (with 30 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 71). This optimal management regime will generate the maximum SEV of -$161.94 (Table 79), with a NPW of -$158.44 per acre (Table 75). This financially optimal rotation could produce an estimated 2,912.14 cubic feet of pulpwood and 18.70 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 58.61 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 27 and 35 (with 35 percent of basal area removed) and a final harvest at stand age 51 are conducted (Table 71). This optimal management regime will generate the maximum SEV of -$307.04 (Table 79), with a NPW of -$304.08 per acre (Table 75). This financially optimal rotation could produce an estimated 3,057.84 cubic feet of pulpwood and 16.95 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 56.86 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 25 and 30 (with 35 percent of basal area removed) and a final harvest at stand age 49 are conducted (Table 71). This optimal management regime will generate the maximum SEV of -$350.98 (Table 79), with a NPW of -$350.01 per acre (Table 75). This financially optimal rotation could produce an estimated 2,974.82 cubic feet of pulpwood and 14.07 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 52.19 net tons of carbon per acre during one rotation (Table 67).

Northern red oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 25 and 30 (with 35 percent of basal area removed) and a final harvest at stand age 48 are conducted (Table 71). This

optimal management regime will generate the maximum SEV of -$365.74 (Table 79), with a NPW of -$365.35 per acre (Table 75). This financially optimal rotation could produce an estimated 3,126.26 cubic feet of pulpwood and 12.57 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 50.79 net tons of carbon per acre during one rotation (Table 67).

Southern- Northern red oak - Timber + Carbon Rotations (C = $10/ton)

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 50 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 72). This optimal management regime will generate the maximum SEV of $2,691.93 (Table 80), with a NPW of $2,095.02 per acre (Table 76). This means that $2,691.93 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,095.02 per acre for managing one rotation, or $2,691.93 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 2,884.81 cubic feet of pulpwood and 18.04 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 53.69 net tons of carbon per acre during one rotation (Table 68). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 50 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 72). This optimal management regime will generate the maximum SEV of $335.81 (Table 80), with a NPW of $318.69 per acre (Table 76). This financially optimal rotation could produce an estimated 2,884.81 cubic feet of pulpwood and 18.04 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 53.69 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 35 and 44 (with 25 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 72). This optimal management regime will generate the maximum SEV of -$138.71 (Table 80), with a NPW of -$136.90 per acre (Table 76). This financially optimal rotation could produce an estimated 2,664.10 cubic feet of pulpwood and 16.90 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 50.62 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 33 and 44 (with 35 percent of basal area removed) and a final harvest at stand age 56 are conducted (Table 72). This optimal management regime will generate the maximum SEV of -$267.87 (Table 80), with a NPW of -$266.70 per acre (Table 76). This financially optimal rotation could produce an estimated 2,963.93 cubic feet of pulpwood and 13.74 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 48.05 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 33 and 44 (with 35 percent of basal area removed) and a final harvest at stand age 56 are conducted (Table 72). This optimal management regime will generate the maximum SEV of -$314.55 (Table 80), with a NPW of -$314.71 per acre (Table 76). This financially optimal rotation could produce an estimated 2,963.93 cubic feet of pulpwood and 13.74 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 48.05 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 33 and 44 (with 35 percent of basal area removed) and a final harvest at stand age 56 are conducted (Table 72). This optimal management regime will generate the maximum SEV of -$335.17 (Table 80), with a NPW of -$335.06 per acre (Table 76). This financially optimal rotation could produce an estimated 2,963.93 cubic feet of pulpwood and 13.74 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 48.05 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 34 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 72). This optimal management regime will generate the maximum SEV of $3,567.63 (Table 80), with a NPW of $2,776.54 per acre (Table 76). This financially optimal rotation could produce an estimated 2,193.40 cubic feet of pulpwood and 24.04 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 59.78 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 34 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 72). This optimal

management regime will generate the maximum SEV of $534.49 (Table 80), with a NPW of $507.24 per acre (Table 76). This financially optimal rotation could produce an estimated 2,193.40 cubic feet of pulpwood and 24.04 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 59.78 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 34 and 40 (with 30 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 72). This optimal management regime will generate the maximum SEV of -$69.31 (Table 80), with a NPW of -$67.91 per acre (Table 76). This financially optimal rotation could produce an estimated 3,081.12 cubic feet of pulpwood and 15.95 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 53.87 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 34 and 40 (with 30 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 72). This optimal management regime will generate the maximum SEV of -$233.05 (Table 80), with a NPW of -$231.69 per acre (Table 76). This financially optimal rotation could produce an estimated 3,081.12 cubic feet of pulpwood and 15.95 MBF of sawlogs per

acre from the thinning and final harvest (Table 84), and sequester 53.87 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 30 and 37 (with 30 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 72). This optimal management regime will generate the maximum SEV of -$306.63 (Table 80), with a NPW of -$305.79 per acre (Table 76). This financially optimal rotation could produce an estimated 3,049.80 cubic feet of pulpwood and 14.51 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 51.54 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 30 and 37 (with 30 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 72). This optimal management regime will generate the maximum SEV of -$321.69 (Table 80), with a NPW of -$321.49 per acre (Table 76). This financially optimal rotation could produce an estimated 3,149.80 cubic feet of pulpwood and 14.51 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 51.54 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 29 and 55 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 72). This optimal management regime will generate the maximum SEV of $4,173.20 (Table 80), with a NPW of $3,247.84 per acre (Table 76). This financially optimal rotation could produce an estimated 2,449.55 cubic feet of pulpwood and 27.40 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 68.41 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 33 and 55 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 72). This optimal management regime will generate the maximum SEV of $697.47 (Table 80), with a NPW of $661.91 per acre (Table 76). This financially optimal rotation could produce an estimated 2,582.77 cubic feet of pulpwood and 21.36 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 68.76 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning at stand age 29 (with 25 percent of basal area removed) and a final harvest at stand age 55 are conducted (Table 72). This optimal management regime will generate the maximum SEV of $0.64 (Table 80), with a NPW of $0.63 per acre (Table 76). This financially optimal rotation could produce an estimated 1,892.40 cubic feet of pulpwood and 23.36 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 62.67 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 31 and 37 (with 30 percent of basal area removed) and a final harvest at stand age 51 are conducted (Table 72). This optimal management regime will generate the maximum SEV of -$198.41 (Table 80), with a NPW of -$197.02 per acre (Table 76). This financially optimal rotation could produce an estimated 3,173.53 cubic feet of pulpwood and 17.40 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 58.43 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 29 and 37 (with 30 percent of basal area removed) and a final harvest at stand age 50 are conducted (Table 72). This

optimal management regime will generate the maximum SEV of -$273.16 (Table 80), with a NPW of -$272.49 per acre (Table 76). This financially optimal rotation could produce an estimated 3,311.26 cubic feet of pulpwood and 16.00 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 56.93 net tons of carbon per acre during one rotation (Table 68).

Northern red oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 27 and 32 (with 30 percent of basal area removed) and a final harvest at stand age 49 are conducted (Table 72). This optimal management regime will generate the maximum SEV of -$307.04 (Table 80), with a NPW of -$306.75 per acre (Table 76). This financially optimal rotation could produce an estimated 3,334.49 cubic feet of pulpwood and 14.29 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 54.13 net tons of carbon per acre during one rotation (Table 68).

<u>Southern- Northern red oak - Timber + Carbon Rotations (C = $37/ton)</u>

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 50 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 73). This optimal management regime will generate the maximum SEV of $3,808.05 (Table 81), with a

NPW of $2,963.65 per acre (Table 77). This means that $3,808.05 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,963.65 per acre for managing one rotation, or $3,808.05 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 2,884.81 cubic feet of pulpwood and 18.04 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 53.69 net tons of carbon per acre during one rotation (Table 69). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 50 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 73). This optimal management regime will generate the maximum SEV of $875.45 (Table 81), with a NPW of $830.81 per acre (Table 77). This financially optimal rotation could produce an estimated 2,884.81 cubic feet of pulpwood and 18.04 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 53.69 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning at stand age 50 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 73). This optimal management regime will generate the maximum SEV of $179.00 (Table 81), with a NPW of $176.83 per acre (Table 77). This financially optimal rotation could produce an estimated 2,884.81 cubic feet of pulpwood and 18.04 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 53.69 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 50 (with 25 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 73). This optimal management regime will generate the maximum SEV of -$65.01 (Table 81), with a NPW of -$64.80 per acre (Table 77). This financially optimal rotation could produce an estimated 2,897.27 cubic feet of pulpwood and 17.23 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 52.28 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 50 (with 25 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 73). This optimal

management regime will generate the maximum SEV of -$174.40 (Table 81), with a NPW of -$174.26 per acre (Table 77). This financially optimal rotation could produce an estimated 2,897.27 cubic feet of pulpwood and 17.23 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 52.28 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 50 (with 25 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 73). This optimal management regime will generate the maximum SEV of -$232.81 (Table 81), with a NPW of -$232.76 per acre (Table 77). This financially optimal rotation could produce an estimated 2,897.27 cubic feet of pulpwood and 17.23 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 52.28 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 44 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 73). This optimal management regime will generate the maximum SEV of $4,861.78 (Table 81), with a NPW of $3,783.73 per acre (Table 77). This financially optimal rotation could produce an estimated 2,535.61 cubic feet of pulpwood and 23.63 MBF of sawlogs per acre from

the thinning and final harvest (Table 85), and sequester 61.72 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 44 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 73). This optimal management regime will generate the maximum SEV of $1,181.73 (Table 81), with a NPW of $1,121.47 per acre (Table 77). This financially optimal rotation could produce an estimated 2,535.61 cubic feet of pulpwood and 23.63 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 61.72 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning at stand age 46 (with 25 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 73). This optimal management regime will generate the maximum SEV of $319.06 (Table 81), with a NPW of $314.89 per acre (Table 77). This financially optimal rotation could produce an estimated 2,601.74 cubic feet of pulpwood and 22.56 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 60.44 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 48 (with 30 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 73). This optimal management regime will generate the maximum SEV of $19.00 (Table 81), with a NPW of $18.93 per acre (Table 77). This financially optimal rotation could produce an estimated 2,973.45 cubic feet of pulpwood and 19.83 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 58.81 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 47 (with 30 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 73). This optimal management regime will generate the maximum SEV of -$116.37 (Table 81), with a NPW of -$116.17 per acre (Table 77). This financially optimal rotation could produce an estimated 3,742.24 cubic feet of pulpwood and 14.16 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 55.17 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 47 (with 30 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 73). This optimal management regime will generate the maximum SEV of -$189.47 (Table 81), with a NPW of -$189.37 per acre (Table 77). This financially optimal rotation could produce an estimated 3,742.24 cubic feet of pulpwood and 14.15 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 55.17 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 29 and 55 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 73). This optimal management regime will generate the maximum SEV of $5,646.79 (Table 81), with a NPW of $4,394.67 per acre (Table 77). This financially optimal rotation could produce an estimated 2,449.55 cubic feet of pulpwood and 23.22 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 68.41 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 42 (with 25 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 73). This optimal

management regime will generate the maximum SEV of $1,457.64 (Table 81), with a NPW of $1,375.70 per acre (Table 77). This financially optimal rotation could produce an estimated 2,688.10 cubic feet of pulpwood and 25.94 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 68.28 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning at stand age 41 (with 25 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 73). This optimal management regime will generate the maximum SEV of $461.73 (Table 81), with a NPW of $454.77 per acre (Table 77). This financially optimal rotation could produce an estimated 2,672.32 cubic feet of pulpwood and 25.11 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 66.87 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 45 (with 30 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 73). This optimal management regime will generate the maximum SEV of $108.73 (Table 81), with a NPW of $108.09 per acre (Table 77). This financially optimal rotation could produce an estimated 3,253.50 cubic feet of pulpwood and 19.74 MBF of sawlogs per acre from the

thinning and final harvest (Table 85), and sequester 62.20 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 45 (with 30 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 73). This optimal management regime will generate the maximum SEV of -$53.94 (Table 81), with a NPW of -$53.85 per acre (Table 77). This financially optimal rotation could produce an estimated 3,253.50 cubic feet of pulpwood and 19.74 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 62.20 net tons of carbon per acre during one rotation (Table 69).

Northern red oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 44 (with 30 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 73). This optimal management regime will generate the maximum SEV of -$142.96 (Table 81), with a NPW of -$142.87 per acre (Table 77). This financially optimal rotation could produce an estimated 3,582.22 cubic feet of pulpwood and 17.77 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 61.49 net tons of carbon per acre during one rotation (Table 69).

<u>Southern- Northern red oak - Timber + Carbon Rotations (C = $50/ton)</u>

Northern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 50 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 74). This optimal management regime will generate the maximum SEV of $4,345.44 (Table 82), with a NPW of $3,381.88 per acre (Table 78). This means that $4,345.44 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $3,381.88 per acre for managing one rotation, or $4,345.44 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 2,884.81 cubic feet of pulpwood and 18.04 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 53.69 net tons of carbon per acre during one rotation (Table 70). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Northern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 50 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 74). This optimal

management regime will generate the maximum SEV of $1,135.28 (Table 82), with a NPW of $1,077.39 per acre (Table 78). This financially optimal rotation could produce an estimated 2,884.81 cubic feet of pulpwood and 18.04 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 53.69 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning at stand age 50 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 74). This optimal management regime will generate the maximum SEV of $332.71 (Table 82), with a NPW of $328.67 per acre (Table 78). This financially optimal rotation could produce an estimated 2,884.81 cubic feet of pulpwood and 18.04 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 53.69 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 50 (with 25 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 74). This optimal management regime will generate the maximum SEV of $34.33 (Table 82), with a NPW of $34.20 per acre (Table 78). This financially optimal rotation could produce an estimated 2,897.27 cubic feet of pulpwood and 17.23 MBF of sawlogs per acre from the

thinning and final harvest (Table 86), and sequester 52.28 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 50 (with 25 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 74). This optimal management regime will generate the maximum SEV of -$105.81 (Table 82), with a NPW of -$105.72 per acre (Table 78). This financially optimal rotation could produce an estimated 2,897.27 cubic feet of pulpwood and 17.23 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 52.28 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 50 (with 25 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 74). This optimal management regime will generate the maximum SEV of -$182.95 (Table 82), with a NPW of -$182.91 per acre (Table 78). This financially optimal rotation could produce an estimated 2,897.27 cubic feet of pulpwood and 17.23 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 52.28 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 44 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 74). This optimal management regime will generate the maximum SEV of $5,495.47 (Table 82), with a NPW of $4,276.90 per acre (Table 78). This financially optimal rotation could produce an estimated 2,535.61 cubic feet of pulpwood and 23.63 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 61.72 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 44 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 74). This optimal management regime will generate the maximum SEV of $1,495.10 (Table 82), with a NPW of $1,418.87 per acre (Table 78). This financially optimal rotation could produce an estimated 2,535.61 cubic feet of pulpwood and 23.63 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 61.72 net tons of carbon per acre during one rotation (Table 70)

Northern red oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning at stand age 46 (with 25 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 74). This optimal management regime will generate the maximum SEV of $508.42 (Table 82), with a NPW of $501.79 per acre (Table 78). This financially optimal rotation could produce an estimated 2,601.74 cubic feet of pulpwood and 22.56 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 60.44 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 48 (with 30 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 74). This optimal management regime will generate the maximum SEV of $143.81 (Table 82), with a NPW of $143.24 per acre (Table 78). This financially optimal rotation could produce an estimated 2,975.45 cubic feet of pulpwood and 19.83 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 58.81 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 47 (with 25 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 74). This optimal

management regime will generate the maximum SEV of -$29.03 (Table 82), with a NPW of -$29.00 per acre (Table 78). This financially optimal rotation could produce an estimated 3,312.15 cubic feet of pulpwood and 15.21 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 58.38 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 47 (with 30 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 74). This optimal management regime will generate the maximum SEV of -$125.05 (Table 82), with a NPW of -$124.98 per acre (Table 78). This financially optimal rotation could produce an estimated 3,742.24 cubic feet of pulpwood and 14.15 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 55.17 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 44 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 74). This optimal management regime will generate the maximum SEV of $6,365.45 (Table 82), with a NPW of $4,953.97 per acre (Table 78). This financially optimal rotation could produce an estimated 2,736.99 cubic feet of pulpwood and 26.85 MBF of sawlogs per acre from

the thinning and final harvest (Table 86), and sequester 69.80 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 42 (with 25 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 74). This optimal management regime will generate the maximum SEV of $1,824.74 (Table 82), with a NPW of $1,722.17 per acre (Table 78). This financially optimal rotation could produce an estimated 2,688.10 cubic feet of pulpwood and 25.94 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 68.28 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning at stand age 41 (with 25 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 74). This optimal management regime will generate the maximum SEV of $686.55 (Table 82), with a NPW of $676.20 per acre (Table 78). This financially optimal rotation could produce an estimated 2,910.92 cubic feet of pulpwood and 21.14 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 66.87 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 45 (with 30 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 74). This optimal management regime will generate the maximum SEV of $259.28 (Table 82), with a NPW of $257.77 per acre (Table 78). This financially optimal rotation could produce an estimated 3,253.50 cubic feet of pulpwood and 19.74 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 62.20 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 45 (with 30 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 74). This optimal management regime will generate the maximum SEV of $53.50 (Table 82), with a NPW of $53.41 per acre (Table 78). This financially optimal rotation could produce an estimated 3,253.50 cubic feet of pulpwood and 19.74 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 62.20 net tons of carbon per acre during one rotation (Table 70).

Northern red oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 45 (with 30 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 74). This optimal management regime will generate the maximum SEV of -$62.79 (Table 82), with a NPW of -$62.76 per acre (Table 78). This financially optimal rotation could produce an estimated 3,253.50 cubic feet of pulpwood and 19.74 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 62.20 net tons of carbon per acre during one rotation (Table 70).

Paper birch - *Betula papyrifera* Marsh.

Biological information

Paper birch, also known as white birch, canoe birch, or silver birch, is the most widely distributed birch in North America, mostly in Canada. It is a medium-sized, fast-growing tree that grows best on well-drained, sandy loams on cool moist sites (Silvics manual. USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/papyrifera.htm. June 17, 2006).

Paper birch ranges from Newfoundland west to northwest Alaska, south from Kodiak Island in Alaska to British Columbia, and Washington, east in Minnesota, Iowa and Pennsylvania, with small isolated populations further south in mountains to North Carolina and Colorado (Silvics manual USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/papyrifera.htm. June 17, 2006) (Fig. 1).

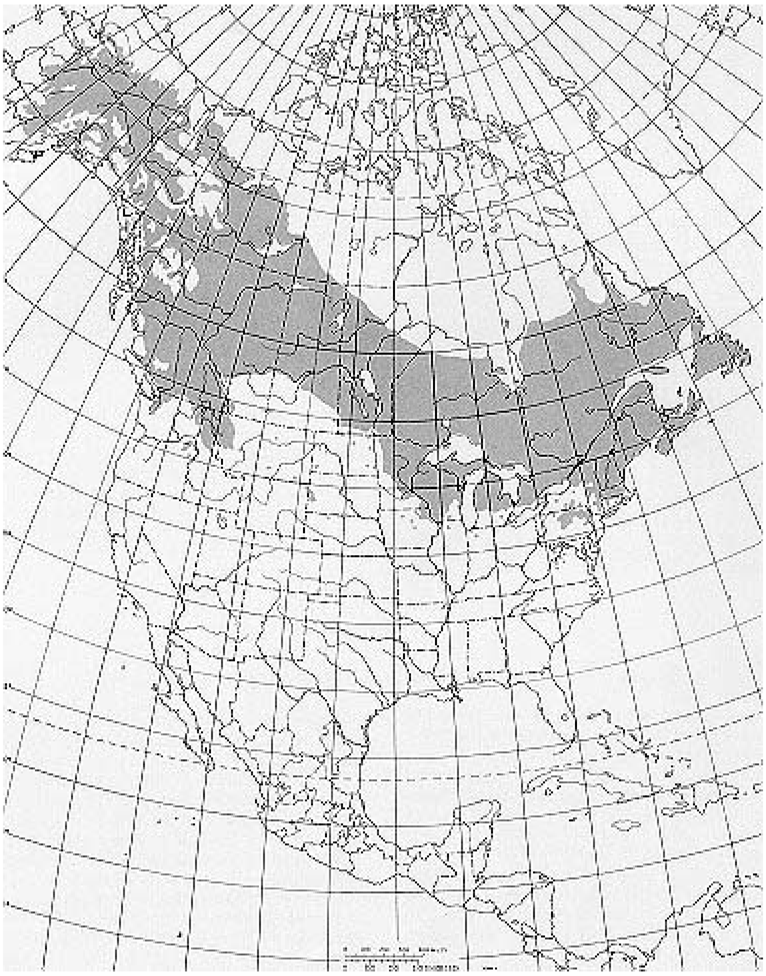

Fig. 1 The native range of paper birch (Silvics manual. USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/papyrifera.htm. June 17, 2006).

Paper birch is a short-lived, fast-growing tree. It reaches a diameter growth of 8 in. in 30 years. In mature stands, trees often reach diameters of 10 to 12 in. and a height of 70 ft. (Silvics manual. USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/papyrifera.htm. June 17, 2006).

On good sites in Alaska, Ontario, and New England, yields of paper birch range from 3,286 to 3,857 ft^3/acre. On poor sites, yields range from about *1,429* to

2,643 ft³/acre. Paper birch demonstrate its greatest yields in New England (Silvics manual□ USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/papyrifera.htm. June 17, 2006).

The range of site index in New England, New York, and the Lake States is from 40 to 80 ft at base age 50 years; and from 35 to 65 ft in Alaska. (Silvics manual□ USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/papyrifera.htm. June 17, 2006).

The lumber of paper birch is often used for veneer, pulpwood, turned articles, woodenware, and fuel. The graceful form attractive white bark and handsome foliage of paper birch make it attractive for ornamental planting and landscaping. North American Indians used the thin, water-impervious bark for roofing and canoes.

Paper birch is also an important source of food for birds (Silvics manual. USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/papyrifera.htm. June 17, 2006).

Economic information

Wang et al (1997) studied the relative growth rate and biomass allocation of paper birch populations under different soil moisture and nutrient regimes. Four geographically diverse populations of paper birch native to British Columbia were chosen along moisture, temperature, and photoperiod gradients. They were grown in a greenhouse for 3 months to examine the relative sensitivity of each population to water and nutrient availability. The results showed that all four populations showed similar height growth patterns. The height growth of the low-elevation coastal population, however, continued to increase in height under all treatment conditions. For all populations combined, relative growth rate was significantly correlated with shoot and foliage biomass, leaf area, and root weight ratio. The authors concluded that soil moisture and soil nutrient should be primarily concerned when allocating birch seed lots in a planting plan.

Gansner el al (1990) conducted a statistical and economic analysis on timber value growth rates in New England to help the forest managers determine financial rates of return for their woodlot. Data from more than 1,100 plots (0.1 to 0.2 acres) that were measured during the early 1970's and remained relatively undisturbed were used to analyze value growth. Compound annual rates of value change were calculated to determine the changes. The results showed that the annual rate of change for all trees sampled averaged 3.2 percent, and white ash, red oak and white ash had the highest rates. The rate for paper birch was 2.6%, which ranked it the ninth overall.

Filip (1967) compared harvesting costs and returns under 4 thinning and harvesting methods (selection, patch, diameter-limit, and commercial clearcutting) in mature beech-birch-maple stands in New England. The experiments were performed by five separate logging contractors over a 14-year period. The results showed that the lowest cost occurred in the diameter-limit cutting. Selection and patch cuttings had much lower dollar returns than the other methods.

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Species ___Paper birch__________ Region ______Lake States__________________

Site indices 60, 70 and 80 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 7.20, 8.05 and, 10.00 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 25 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183553598 and 0.489476260, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Perala and Alban (1994) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$Y = 0.06815D^{2.194}H^{0.4466}*1000$$

where:

Y = component dry-weight (kg.)

D = diameter at breast height (cm.)

H = height (cm.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $115/mbf (International 1/4) (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005) and pulpwood price was assumed to be $17/cord (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of paper birch plantations in the Lake States.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$152.60	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]The seedling cost was estimated based on the seedling prices from Minnesota DNR State Forest Nursery (http://www.dnr.state.mn.us/forestry/nurseries/pricelist.html. January 18, 2006).

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Table 1. Total tons of carbon sequestered per acre for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	18.17	17.92	17.77	17.77	17.36	17.36
70	23.89	20.14	19.83	19.83	19.83	20.14
80	27.69	24.13	22.60	22.60	22.60	22.60

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	18.72	17.92	17.92	17.77	17.77	17.77
70	23.89	21.75	19.83	19.83	19.83	19.83
80	27.87	22.60	22.60	22.60	22.60	22.60

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	18.72	18.55	18.55	18.55	17.21	17.21
70	23.89	23.56	22.96	22.77	20.40	20.50
80	27.87	23.25	23.25	23.30	23.30	23.41

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	18.72	18.55	18.69	17.21	17.21	15.81
70	24.03	23.29	22.77	22.77	18.54	18.08
80	27.87	23.25	23.25	23.29	22.89	22.89

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<47-54-**81**[2]>[3] (30%)[4]	<46-51-**81**> (30%)	<46-51-**80**> (30%)	<46-51-**80**> (30%)	<46-51-**75**> (30%)	<46-51-**75**> (30%)
70	<34-74-**89**> (30%)	<34-44-**68**> (30%)	<34-45-**68**> (30%)	<34-45-**68**> (30%)	<34-45-**68**> (30%)	<34-44-**68**> (30%)
80	<31-65-**83**> (30%)	<30-35-**68**> (30%)	<39-**68**> (20%)	<39-**68**> (20%)	<39-**68**> (20%)	<39-**68**> (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<51-82-**89**[2]>[3] (25%)[4]	<46-51-**81**> (30%)	<46-51-**81**> (30%)	<46-51-**80**> (30%)	<46-51-**80**> (30%)	<46-51-**80**> (30%)
70	34-74-**89** (30%)	<34-45-**79**> (30%)	<34-45-**68**> (30%)	<34-45-**68**> (30%)	<34-45-**68**> (30%)	<34-45-**68**> (30%)
80	30-65-**84** (30%)	<39-**68**> (20%)	<39-**68**> (20%)	<39-**68**> (20%)	<39-**68**> (20%)	<39-**68**> (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3] Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4] Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	51-82-**89**[2] (25%)[3]	<61-84-**89**>[4] (25%)	<61-84-**89**> (25%)	<61-84-**89**> (25%)	<73-**90**> (20%)	<73-**90**> (20%)
70	34-74-**89** (30%)	54-77-**89** (30%)	<54-78-**89**> (25%)	<54-76-**90**> (20%)	<54-**80**> (20%)	<64-**82**> (20%)
80	30-65-**84** (30%)	48-**80** (20%)	48-**80** (20%)	<50-**80**> (20%)	<50-**80**> (20%)	<58-**80**> (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	51-82-**89**[2] (25%)[3]	61-84-**89** (25%)	<61-84-**90**>[4] (25%)	<73-**90**> (20%)	<73-**90**> (20%)	<83-**90**> (20%)
70	36-75-**90** (30%)	54-79-**89** (25%)	54-76-**90** (20%)	<54-76-**90**> (20%)	<83-**90**> (25%)	<83-**90**> (20%)
80	30-65-**84** (30%)	48-**80** (20%)	48-**80** (20%)	50-**81** (20%)	<73-**90**> (20%)	<73-**90**> (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$257.73	-$380.81	-$398.45	-$400.29	-$399.62	-$398.77
70	-$175.55	-$355.79	-$389.70	-$396.65	-$398.24	-$398.14
80	-$84.60	-$334.08	-$370.75	-$376.89	-$377.34	-$376.79

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$115.04	-$284.54	-$332.24	-$352.30	-$363.37	-$370.41
70	$16.21	-$240.34	-$305.79	-$334.79	-$350.53	-$360.42
80	$145.83	-$180.59	-$260.24	-$295.17	-$314.66	-$327.20

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$304.63	-$17.31	-$150.44	-$221.64	-$265.02	-$293.66
70	$533.97	$99.54	-$71.96	-$163.64	-$220.12	-$257.80
80	$769.52	$245.88	$41.00	-$73.25	-$144.81	-$193.04

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$506.69	$114.59	-$61.80	-$158.20	-$217.53	-$256.67
70	$785.76	$268.46	$43.67	-$80.10	-$156.89	-$208.20
80	$1,069.81	$455.67	$187.71	$34.15	-$62.83	-$128.35

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$296.93	-$387.90	-$399.59	-$400.47	-$399.67	-$398.78
70	-$196.89	-$368.51	-$392.37	-$397.50	-$398.36	-$398.17
80	-$96.75	-$346.02	-$373.29	-$377.42	-$377.46	-$376.81

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$129.02	-$289.84	-$333.12	-$352.46	-$363.40	-$370.41
70	$18.18	-$245.29	-$307.88	-$335.25	-$350.64	-$360.44
80	$166.21	-$187.05	-$262.02	-$295.58	-$314.75	-$327.22

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$341.65	-$17.53	-$150.66	-$221.68	-$265.03	-$293.66
70	$598.86	$100.79	-$72.07	-$163.67	-$220.13	-$257.80
80	$877.04	$250.70	$41.11	-$73.28	-$144.82	-$193.04

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for paper birch plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$568.26	$116.03	-$61.89	-$158.33	-$217.54	-$256.67
70	$878.64	$271.83	$43.73	-$80.12	-$156.89	-$208.20
80	$1,219.29	$464.60	$188.25	$34.16	-$62.83	-$128.35

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for paper birch plantations by soil productivity and real alternative rates of return in the Lakes States region of the United States. (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	<47-54-**81**[2]>[3] (30%)[4]	694.74	0	566.15	0	1,361.15	19.62	2,622.04	6.55
	5.0%	<46-51-**81**> (30%)	665.69	0	553.29	0	1,354.65	14.10	2,573.63	6.48
	7.5%	<46-51-**80**> (30%)	665.69	0	553.29	0	1,379.62	13.18	2,598.60	6.18
	10.0%	<46-51-**80**> (30%)	665.69	0	553.29	0	1,379.62	12.32	2,598.60	6.18
	12.5%	<46-51-**75**> (30%)	665.69	0	553.29	0	1,885.62	12.32	3,104.60	3.77
	15.0%	<46-51-**75**> (30%)	665.69	0	553.29	0	1,885.62	12.32	3,104.60	3.77
70	2.5%	<34-74-**89**> (30%)	584.19	0	661.88	2.45	1,655.68	10.47	2,901.75	12.92
	5.0%	<34-44-**68**> (30%)	584.19	0	580.37	0	1,736.60	6.41	2,901.16	6.41
	7.5%	<34-45-**68**> (30%)	584.19	0	676.03	0	1,680.92	6.20	2,941.14	6.20
	10.0%	<34-45-**68**> (30%)	584.19	0	676.03	0	1,680.92	6.20	2,941.14	6.20
	12.5%	<34-45-**68**> (30%)	584.19	0	676.03	0	1,680.92	6.20	2,941.14	6.20
	15.0%	<34-44-**68**> (30%)	584.19	0	580.37	0	1,736.60	6.41	2,901.16	6.41
80	2.5%	<31-65-**83**> (30%)	585.79	0	769.23	2.37	1,603.49	13.67	2,958.51	16.04
	5.0%	<30-35-**68**> (30%)	575.51	0	584.73	0	1,704.22	9.82	2,864.46	9.82
	7.5%	<39-**68**> (20%)	554.92	0	-[5]	-	2,700.01	7.81	3,254.93	7.81
	10.0%	<39-**68**> (20%)	554.92	0	-	-	2,700.01	7.81	3,254.93	7.81
	12.5%	<39-**68**> (20%)	554.92	0	-	-	2,700.01	7.81	3,254.93	7.81
	15.0%	<39-**68**> (20%)	554.92	0	-	-	2,700.01	7.81	3,254.93	7.81

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 18. Volume removed from the financially optimal schedules for paper birch plantations by soil productivity and real alternative rates of return in the Lakes States region of the United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	<51-82-**89**[2]>[3] (25%)[4]	622.83	0	616.53	1.23	1,382.84	6.70	2,622.20	7.93
	5.0%	<46-51-**81**> (30%)	665.69	0	553.29	0	1,345.65	6.48	2,564.63	6.48
	7.5%	<46-51-**81**> (30%)	665.69	0	553.29	0	1,345.65	6.48	2,564.63	6.48
	10.0%	<46-51-**80**> (30%)	665.69	0	553.29	0	1,379.62	6.18	2,598.60	6.18
	12.5%	<46-51-**80**> (30%)	665.69	0	553.29	0	1,379.62	6.18	2,598.60	6.18
	15.0%	<46-51-**80**> (30%)	665.69	0	553.29	0	1,379.62	6.18	2,598.60	6.18
70	2.5%	34-74-**89** (30%)	584.19	0	661.88	2.45	1,655.68	10.47	2,901.75	12.92
	5.0%	<34-45-**79**> (30%)	584.19	0	676.03	0	1,323.12	9.98	2,583.34	9.98
	7.5%	<34-45-**68**> (30%)	584.19	0	676.03	0	1,680.92	6.20	2,941.14	6.20
	10.0%	<34-45-**68**> (30%)	584.19	0	676.03	0	1,680.92	6.20	2,941.14	6.20
	12.5%	<34-45-**68**> (30%)	584.19	0	676.03	0	1,680.92	6.20	2,941.14	6.20
	15.0%	<34-45-**68**> (30%)	584.19	0	676.03	0	1,680.92	6.20	2,941.14	6.20
80	2.5%	30-65-**84** (30%)	575.51	0	770.16	2.37	1,643.50	13.93	2,989.17	16.30
	5.0%	<39-**68**> (20%)	554.92	0	-[5]	-	2,700.01	7.81	3,254.93	7.81
	7.5%	<39-**68**> (20%)	554.92	0	-	-	2,700.01	7.81	3,254.93	7.81
	10.0%	<39-**68**> (20%)	554.92	0	-	-	2,700.01	7.81	3,254.93	7.81
	12.5%	<39-**68**> (20%)	554.92	0	-	-	2,700.01	7.81	3,254.93	7.81
	15.0%	<39-**68**> (20%)	554.92	0	-	-	2,700.01	7.81	3,254.93	7.81

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for paper birch plantations by soil productivity and real alternative rates of return in the Lakes States region of the United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	<51-82-**89**[3]> (25%)[4]	616.53	0	616.53	1.23	1,382.84	6.70	2,622.20	7.93
	5.0%	<61-84-**89**> (25%)	715.69	0	598.84	1.20	1,321.34	6.35	2,635.87	7.55
	7.5%	<61-84-**89**> (25%)	715.69	0	598.84	1.20	1,321.34	6.35	2,635.87	7.55
	10.0%	<61-84-**89**> (25%)	715.69	0	598.84	1.20	1,321.34	6.35	2,635.87	7.55
	12.5%	<73-**90**> (20%)	683.37	0	-[5]	-	2,383.59	5.05	3,066.96	5.05
	15.0%	<73-**90**> (20%)	683.37	0	-	-	2,383.59	5.05	3,066.96	5.05
70	2.5%	34-74-**89** (30%)	584.19	0	661.88	2.45	1,655.68	10.47	2,901.75	12.92
	5.0%	54-77-**89** (30%)	1,001.44	0	622.28	2.29	1,221.81	9.28	2,845.53	11.57
	7.5%	<54-78-**89**> (25%)	834.49	0	573.20	1.95	1,309.86	9.67	2,717.55	11.62
	10.0%	<54-76-**90**> (20%)	667.55	0	597.02	1.01	1,726.55	9.48	2,991.12	10.49
	12.5%	<54-**80**> (20%)	667.55	0	-	-	2,213.17	8.19	2,880.72	8.19
	15.0%	<64-**82**> (20%)	693.19	0	-	-	2,210.60	8.23	2,903.79	8.23
80	2.5%	30-65-**84** (30%)	575.51	0	770.16	2.37	1,643.50	13.93	2,989.17	16.30
	5.0%	48-**80** (20%)	665.45	0	-	-	2,003.38	11.21	2,668.83	11.21
	7.5%	48-**80** (20%)	665.45	0	-	-	2,003.38	11.21	2,668.83	11.21
	10.0%	<50-**80**> (20%)	742.98	0	-	-	2,015.37	11.16	2,758.35	11.16
	12.5%	<50-**80**> (20%)	742.98	0	-	-	2,015.37	11.16	2,758.35	11.16
	15.0%	<58-**80**> (20%)	777.21	0	-	-	2,031.30	11.08	2,808.51	11.08

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for paper birch plantations by soil productivity and real alternative rates of return in the Lakes States region of the United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	<51-82-**89**[3]> (25%)[4]	622.83	0	616.53	1.23	1,382.84	6.70	2,622.20	7.93
	5.0%	<61-84-**89**> (25%)	715.69	0	598.84	1.20	1,321.34	6.35	2,635.87	7.55
	7.5%	<61-84-**90**> (25%)	715.69	0	598.84	1.20	1,337.77	6.46	2,652.30	7.66
	10.0%	<73-**90**> (20%)	683.37	0	-[5]	0	2,383.59	5.05	3,066.96	5.05
	12.5%	<73-**90**> (20%)	683.37	0	-	-	2,383.59	5.05	3,066.96	5.05
	15.0%	<83-**90**> (20%)	696.25	0	-	-	2,169.17	4.48	2,865.42	4.48
70	2.5%	36-75-**90** (30%)	611.78	0	664.11	2.46	1,724.67	10.52	3,000.56	12.98
	5.0%	54-79-**89** (25%)	834.49	0	553.25	2.04	1,423.39	9.51	2,811.13	11.55
	7.5%	54-76-**90** (20%)	667.55	0	597.02	1.01	1,726.55	9.48	2,991.12	10.49
	10.0%	<54-76-**90**> (20%)	667.55	0	597.02	1.01	1,726.55	9.48	2,991.12	10.49
	12.5%	<83-**90**> (25%)	553.03	2.04	-	-	1,845.68	7.04	2,398.71	9.08
	15.0%	<83-**90**> (20%)	442.39	1.63	-	-	1,895.55	7.22	2,337.94	8.85
80	2.5%	30-65-**84** (30%)	575.51	0	770.16	2.37	1,643.50	13.93	2,989.17	16.30
	5.0%	48-**80** (20%)	665.45	0	-	-	2,003.38	11.21	2,668.83	11.21
	7.5%	48-**80** (20%)	665.45	0	-	-	2,003.38	11.21	2,668.83	11.21
	10.0%	50-**81** (20%)	742.98	0	-	-	1,971.32	11.41	2,714.30	11.41
	12.5%	<73-**90**> (20%)	554.52	1.50	-	-	1,891.10	11.63	2,445.62	13.13
	15.0%	<73-**90**> (20%)	554.52	1.50	-	-	1,891.10	11.63	2,445.62	13.13

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for sugar maple plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	60	<47-54-**81**[2]>[3] (30%)[4]	<51-82-**89**> (25%)	10%	51-82-**89** (25%)	10%	51-82-**89** (25%)	10%
	70	<34-74-**89**> (30%)	34-74-**89** (30%)	0%	34-74-**89** (30%)	0%	36-75-**90** (30%)	1%
	80	<31-65-**83**> (30%)	30-65-**84** (30%)	1%	30-65-**84** (30%)	1%	30-65-**84** (30%)	1%
5.00%	60	<46-51-**81**> (30%)	<46-51-**81**> (30%)	0%	<61-84-**89**> (25%)	10%	61-84-**89** (25%)	10%
	70	<34-44-**68**> (30%)	<34-45-**79**> (30%)	16%	54-77-**89** (30%)	31%	54-79-**89** (25%)	31%
	80	<30-35-**68**> (30%)	<39-**68**> (20%)	0%	48-**80** (20%)	18%	48-**80** (20%)	18%
7.50%	60	<46-51-**80**> (30%)	<46-51-**81**> (30%)	1%	<61-84-**89**> (25%)	11%	<61-84-**90**> (25%)	13%
	70	<34-45-**68**> (30%)	<34-45-**68**> (30%)	0%	<54-78-**89**> (25%)	31%	54-76-**90** (20%)	32%
	80	<39-**68**> (20%)	<39-**68**> (20%)	0%	48-**80** (20%)	18%	48-**80** (20%)	18%
10.00%	60	<46-51-**80**> (30%)	<46-51-**80**> (30%)	0%	<61-84-**89**> (25%)	11%	<73-**90**> (20%)	13%
	70	<34-45-**68**> (30%)	<34-45-**68**> (30%)	0%	<54-76-**90**> (20%)	32%	<54-76-**90**> (20%)	32%
	80	<39-**68**> (20%)	<39-**68**> (20%)	0%	<50-**80**> (20%)	18%	50-**81** (20%)	19%
12.50%	60	<46-51-**75**> (30%)	<46-51-**80**> (30%)	7%	<73-**90**> (20%)	20%	<73-**90**> (20%)	20%
	70	<34-45-**68**> (30%)	<34-45-**68**> (30%)	0%	<54-**80**> (20%)	18%	<83-**90**> (25%)	32%
	80	<39-**68**> (20%)	<39-**68**> (20%)	0%	<50-**80**> (20%)	18%	<73-**90**> (20%)	32%
15.00%	60	<46-51-**75**> (30%)	<46-51-**80**> (30%)	7%	<73-**90**> (20%)	20%	<83-**90**> (20%)	20%
	70	<34-44-**68**> (30%)	<34-45-**68**> (30%)	0%	<64-**82**> (20%)	21%	<83-**90**> (20%)	32%
	80	<39-**68**> (20%)	<39-**68**> (20%)	0%	<58-**80**> (20%)	18%	<73-**90**> (20%)	32%

[1] Base age 50.
[2] Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3] <> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.
[4] Number in parentheses indicates the percentage of basal area removed during thinning

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for paper birch plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	60	-296.93	-129.02		341.65		568.26	
	70	-196.89	18.18		598.86		878.64	
	80	-96.75	166.21		877.04		1,219.29	
5.00%	60	-387.90	-289.84		-17.53		116.03	
	70	-368.51	-245.29		100.79		271.83	
	80	-346.02	-187.05		250.70		464.60	
7.50%	60	-399.59	-333.12		-150.66		-61.89	
	70	-392.37	-307.88		-72.07		43.73	
	80	-373.29	-262.02		41.11		188.25	
10.00%	60	-400.47	-352.46		-221.68		-158.33	
	70	-397.50	-335.25		-163.67		-80.12	
	80	-377.42	-295.58		-73.28		34.16	
12.50%	60	-399.67	-363.40		-265.03		-217.54	
	70	-398.36	-350.64		-220.13		-156.89	
	80	-377.46	-314.75		-144.82		-62.83	
15.00%	60	-398.78	-370.41		-293.66		-256.67	
	70	-398.17	-360.44		-257.80		-208.20	
	80	-376.81	-327.22		-193.04		-128.35	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>Lake States- Paper birch - Timber Only Rotations (C = $0/ton)</u>

Paper birch, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 5). This optimal management regime will generate the maximum SEV of -$296.93 (Table 13), with a NPW of -$257.73 per acre (Table 9). This means that -$296.93 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$257.73 per acre for managing one rotation, or -$296.93 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,622.04 cubic feet of pulpwood and 6.55 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 18.17 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Paper birch, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 5). This optimal management regime will generate the maximum SEV of -$387.90 (Table 13), with a NPW of -$380.81 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,564.63 cubic feet of pulpwood and 6.48 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 17.92 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 5). This optimal management regime will generate the maximum SEV of -$399.59 (Table 13), with a NPW of -$398.45 per acre (Table 9). This financially optimal rotation would produce an estimated 2,598.60 cubic feet of pulpwood and 6.18 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 17.77 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 5). This optimal management regime will generate the maximum SEV of -$400.47 (Table 13), with a NPW of -$400.29 per acre (Table 9). This financially optimal rotation would produce an estimated 2,598.60 cubic feet of pulpwood and 6.18 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 17.77 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 5). This optimal management regime will generate the maximum SEV of -$399.67 (Table 13), with a NPW of -$399.62 per acre (Table 9). This financially optimal rotation would produce an estimated 3,104.60 cubic feet of pulpwood and 3.77 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 17.36 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 5). This optimal management regime will generate the maximum SEV of -$398.78 (Table 13), with a NPW of -$398.77 per acre (Table 9). This financially optimal rotation would produce an estimated 3,104.60 cubic feet of pulpwood and 3.77 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 17.36 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 74 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 5). This optimal management regime will generate the maximum SEV of -$196.89 (Table 13), with a NPW of -$175.55 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,901.75 cubic feet of pulpwood and 12.92 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.89 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 5). This optimal management regime will generate the maximum SEV of -$368.51 (Table 13), with a NPW of -$355.79 per acre (Table 9). This financially optimal rotation would produce an estimated 2,901.16 cubic feet of pulpwood and 6.41 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 20.14 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 5). This optimal management regime will generate the maximum SEV of -$392.37 (Table 13), with a NPW of -$389.70 per acre (Table 9). This financially optimal rotation would produce an estimated 2,941.14 cubic feet of pulpwood and 6.20 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.83 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 5). This optimal management regime will generate the maximum SEV of -$397.50 (Table 13), with a NPW of -$396.65 per acre (Table 9). This financially optimal rotation would produce an estimated 2,941.14 cubic feet of pulpwood and 6.20 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.83 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 5). This optimal management regime will generate the maximum SEV of -$398.36 (Table 13), with a NPW of -$398.24 per acre (Table 9). This financially optimal rotation would produce an estimated 2,941.14 cubic feet of pulpwood and 6.20 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.83 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 5). This optimal management regime will generate the maximum SEV of -$398.17 (Table 13), with a NPW of -$398.14 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,901.16 cubic feet of pulpwood and 6.41 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 20.14 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 65 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 5). This optimal management regime will generate the maximum SEV of -$96.75 (Table 13), with a NPW of -$84.60 per acre (Table 9). This financially optimal rotation would produce an estimated 2,958.51 cubic feet of pulpwood and 16.04 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 27.69 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 5). This optimal management regime will generate the maximum SEV of -$346.02 (Table 13), with a NPW of -$334.08 per acre (Table 9). This financially optimal rotation would produce an estimated 2,864.46 cubic feet of pulpwood and 9.82 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 24.13 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 39 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 5). This optimal management regime will generate the maximum SEV of -$373.29 (Table 13), with a NPW of -$370.75 per acre (Table 9). This financially optimal rotation would produce an estimated 3,254.93 cubic feet of pulpwood and 7.81 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.60 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 39 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 5). This optimal management regime will generate the maximum SEV of -$377.42 (Table 13), with a NPW of -$376.89 per acre (Table 9). This financially optimal rotation would produce an estimated 3,254.93 cubic feet of pulpwood and 7.81 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.60 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 39 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 5). This optimal management regime will generate the maximum SEV of -$377.46 (Table 13), with a NPW of -$377.34 per acre (Table 9). This financially optimal rotation would

produce an estimated 3,254.93 cubic feet of pulpwood and 7.81 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.60 net tons of carbon per acre during one rotation (Table 1).

Paper birch, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 39 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 5). This optimal management regime will generate the maximum SEV of -$376.81 (Table 13), with a NPW of -$376.79 per acre (Table 9). This financially optimal rotation would produce an estimated 3,254.93 cubic feet of pulpwood and 7.81 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.60 net tons of carbon per acre during one rotation (Table 1).

<u>Lake States- Paper birch - Timber Only Rotations (C = $10/ton)</u>

Paper birch, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 82 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$219.02 (Table 14), with a NPW of -$115.04 per acre (Table 10). This means that -$219.02 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on

every dollar invested plus -\$115.04 per acre for managing one rotation, or -\$219.02 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,622.20 cubic feet of pulpwood and 7.93 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 18.72 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Paper birch, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 6). This optimal management regime will generate the maximum SEV of -\$289.84 (Table 14), with a NPW of -\$284.54 per acre (Table 10). This financially optimal rotation would produce an estimated 2,564.63 cubic feet of pulpwood and 6.48 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 17.92 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 6). This optimal management regime will generate the maximum SEV of -\$333.12 (Table 14), with a NPW of -\$332.24 per acre (Table 10). This financially optimal rotation would produce an estimated 2,564.63 cubic feet of pulpwood and 6.48 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 17.92 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 6). This optimal management regime will generate the maximum SEV of -$352.46 (Table 14), with a NPW of -$352.30 per acre (Table 10). This financially optimal rotation would produce an estimated 2,598.60 cubic feet of pulpwood and 6.18 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 17.77 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 6). This optimal management regime will generate the maximum SEV of -$363.40 (Table 14), with a NPW of -$363.37 per acre (Table 10). This financially optimal rotation would produce an estimated 2,598.60 cubic feet of pulpwood and 6.18 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 17.77 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 51 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 6). This optimal management regime will generate the maximum SEV of -\$370.41 (Table 14), with a NPW of -\$370.41 per acre (Table 10). This financially optimal rotation would produce an estimated 2,598.60 cubic feet of pulpwood and 6.18 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 17.77 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 74 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of \$18.18 (Table 14), with a NPW of \$16.21 per acre (Table 10). This financially optimal rotation would produce an estimated 2,901.75 cubic feet of pulpwood and 12.92 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.89 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 6). This optimal management regime will generate the maximum SEV of -\$245.29 (Table 14), with a NPW of -\$240.34 per acre (Table 10). This financially optimal rotation would produce an estimated 2,583.34 cubic feet of pulpwood and 9.98 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 21.75 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 6). This optimal management regime will generate the maximum SEV of -$307.88 (Table 14), with a NPW of -$305.79 per acre (Table 10). This financially optimal rotation would produce an estimated 2,941.14 cubic feet of pulpwood and 6.20 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.83 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 6). This optimal management regime will generate the maximum SEV of -$335.25 (Table 14), with a NPW of -$334.79 per acre (Table 10). This financially optimal rotation would produce an estimated 2,941.14 cubic feet of pulpwood and 6.20 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.83 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 45 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 6). This optimal management regime will generate the maximum SEV of -$350.64 (Table 14), with a NPW of -$350.53 per acre (Table 10). This financially optimal rotation would produce an estimated 2,941.14 cubic feet of pulpwood and 6.20 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.83 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 6). This optimal management regime will generate the maximum SEV of -$360.44 (Table 14), with a NPW of -$360.42 per acre (Table 10). This financially optimal rotation would produce an estimated 2,941.14 cubic feet of pulpwood and 6.20 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.83 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 65 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 6). This optimal management regime will generate the maximum SEV of $166.21 (Table 14), with a NPW of $145.83 per acre (Table 10). This financially optimal rotation would produce an estimated 2,989.17 cubic feet of pulpwood and 16.30 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 27.87 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 39 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 6). This optimal management regime will generate the maximum SEV of -$187.05 (Table 14), with a NPW of -$180.59 per acre (Table 10). This financially optimal rotation would produce an estimated 3,254.93 cubic feet of pulpwood and 7.81 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.60 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 39 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 6). This optimal management regime will generate the maximum SEV of -$262.02 (Table 14), with a NPW of -$260.24 per acre (Table 10). This financially optimal rotation would produce an estimated 3,254.93 cubic feet of pulpwood and 7.81 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.60 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 39 (with 20 percent of

basal area removed) and a final harvest is conducted at stand age 68 (Table 6). This optimal management regime will generate the maximum SEV of -$295.58 (Table 14), with a NPW of -$295.17 per acre (Table 10). This financially optimal rotation would produce an estimated 3,254.93 cubic feet of pulpwood and 7.81 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.60 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 39 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 6). This optimal management regime will generate the maximum SEV of -$314.75 (Table 14), with a NPW of -$314.66 per acre (Table 10). This financially optimal rotation would produce an estimated 3,254.93 cubic feet of pulpwood and 7.81 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.60 net tons of carbon per acre during one rotation (Table 2).

Paper birch, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 39 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 6). This optimal management regime will generate the maximum SEV of -$327.22 (Table 14), with a NPW of -$327.20 per acre (Table 10). This financially optimal rotation would produce an estimated 3,254.93 cubic feet of pulpwood and 7.81 MBF of sawlogs per acre

from the thinning and final harvest (Table 18), and sequester 22.60 net tons of carbon per acre during one rotation (Table 2).

Lake States-Paper birch - Timber Only Rotations (C = $37/ton)

Paper birch, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 82 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of $341.65 (Table 15), with a NPW of $304.63 per acre (Table 11). This means that $341.65 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $304.63 per acre for managing one rotation, or $341.65 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,622.20 cubic feet of pulpwood and 7.93 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 18.72 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Paper birch, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 61 and 84 (with 25

percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of -$17.53 (Table 15), with a NPW of -$17.31 per acre (Table 11). This financially optimal rotation would produce an estimated 2,635.87 cubic feet of pulpwood and 7.55 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 18.55 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 61 and 84 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of -$150.66 (Table 15), with a NPW of -$150.44 per acre (Table 11). This financially optimal rotation would produce an estimated 2,635.87 cubic feet of pulpwood and 7.55 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 18.55 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 61 and 84 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of -$221.68 (Table 15), with a NPW of -$221.64 per acre (Table 11). This financially optimal rotation would produce an estimated 2,635.87 cubic feet of pulpwood and 7.55 MBF of sawlogs

per acre from the thinning and final harvest (Table 19), and sequester 18.55 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$265.03 (Table 15), with a NPW of -$265.02 per acre (Table 11). This financially optimal rotation would produce an estimated 3,066.96 cubic feet of pulpwood and 5.05 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 17.21 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$293.66 (Table 15), with a NPW of -$293.66 per acre (Table 11). This financially optimal rotation would produce an estimated 3,066.96 cubic feet of pulpwood and 5.05 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 17.21 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 74 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of $598.86 (Table 15), with a NPW of $533.97 per acre (Table 11). This financially optimal rotation would produce an estimated 2,901.75 cubic feet of pulpwood and 12.92 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.89 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 54 and 77 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of $100.79 (Table 15), with a NPW of $99.54 per acre (Table 11). This financially optimal rotation would produce an estimated 2,845.93 cubic feet of pulpwood and 11.57 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.56 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 54 and 78 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of -$72.07 (Table 15), with a NPW of -$71.96 per acre (Table 11). This financially optimal rotation would produce an estimated 2,717.55 cubic feet of pulpwood and 11.62 MBF of sawlogs per

acre from the thinning and final harvest (Table 19), and sequester 22.96 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 54 and 76 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$163.67 (Table 15), with a NPW of -$163.64 per acre (Table 11). This financially optimal rotation would produce an estimated 2,991.12 cubic feet of pulpwood and 10.49 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 22.77 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 54 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 7). This optimal management regime will generate the maximum SEV of -$220.13 (Table 15), with a NPW of -$220.12 per acre (Table 11). This financially optimal rotation would produce an estimated 2,880.72 cubic feet of pulpwood and 8.19 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 20.40 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 64 (with 20 percent of

basal area removed) and a final harvest is conducted at stand age 82 (Table 7). This optimal management regime will generate the maximum SEV of -$257.80 (Table 15), with a NPW of -$257.80 per acre (Table 11). This financially optimal rotation would produce an estimated 2,903.79 cubic feet of pulpwood and 8.23 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 20.50 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 65 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 7). This optimal management regime will generate the maximum SEV of $877.04 (Table 15), with a NPW of $769.52 per acre (Table 11). This financially optimal rotation would produce an estimated 2,989.17 cubic feet of pulpwood and 16.30 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 27.87 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 48 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 7). This optimal management regime will generate the maximum SEV of $250.70 (Table 15), with a NPW of $245.88 per acre (Table 11). This financially optimal rotation would produce an estimated 2,668.83 cubic feet of pulpwood and 11.21 MBF of sawlogs per

acre from the thinning and final harvest (Table 19), and sequester 23.25 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 48 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 7). This optimal management regime will generate the maximum SEV of $41.11 (Table 15), with a NPW of $41.00 per acre (Table 11). This financially optimal rotation would produce an estimated 2,668.83 cubic feet of pulpwood and 11.21 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.25 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 50 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 7). This optimal management regime will generate the maximum SEV of -$73.28 (Table 15), with a NPW of -$73.25 per acre (Table 11). This financially optimal rotation would produce an estimated 2,758.35 cubic feet of pulpwood and 11.16 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.30 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 50 (with 20 percent of

basal area removed) and a final harvest is conducted at stand age 80 (Table 7). This optimal management regime will generate the maximum SEV of -\$144.82 (Table 15), with a NPW of -\$144.81 per acre (Table 11). This financially optimal rotation would produce an estimated 2,758.35 cubic feet of pulpwood and 11.16 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.30 net tons of carbon per acre during one rotation (Table 3).

Paper birch, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = \$37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 58 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 7). This optimal management regime will generate the maximum SEV of -\$193.04 (Table 15), with a NPW of -\$193.04 per acre (Table 11). This financially optimal rotation would produce an estimated 2,808.51 cubic feet of pulpwood and 11.08 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.41 net tons of carbon per acre during one rotation (Table 3).

<u>Lake States- Paper birch - Timber Only Rotations (C = \$50/ton)</u>

Paper birch, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = \$50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 82 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of \$568.26 (Table 16), with a NPW of \$506.69 per acre (Table 12). This means that \$568.26 is the

maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $506.69 per acre for managing one rotation, or $568.26 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,622.20 cubic feet of pulpwood and 7.93 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 18.72 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Paper birch, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 61 and 84 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of $116.03 (Table 16), with a NPW of $114.59 per acre (Table 12). This financially optimal rotation would produce an estimated 2,635.87 cubic feet of pulpwood and 7.55 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 18.55 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 61 and 84 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8).

This optimal management regime will generate the maximum SEV of -$61.89 (Table 16), with a NPW of -$61.80 per acre (Table 12). This financially optimal rotation would produce an estimated 2,652.30 cubic feet of pulpwood and 7.66 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 18.69 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$158.33 (Table 16), with a NPW of -$158.30 per acre (Table 12). This financially optimal rotation would produce an estimated 3,066.96 cubic feet of pulpwood and 5.05 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 17.21 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$217.54 (Table 16), with a NPW of -$217.53 per acre (Table 12). This financially optimal rotation would produce an estimated 3,066.96 cubic feet of pulpwood and 5.05 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 17.21 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 83 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$256.67 (Table 16), with a NPW of -$256.67 per acre (Table 12). This financially optimal rotation would produce an estimated 2,865.42 cubic feet of pulpwood and 4.48 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 15.81 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 75 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $878.64 (Table 16), with a NPW of $785.76 per acre (Table 12). This financially optimal rotation would produce an estimated 3,000.56 cubic feet of pulpwood and 12.98 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 24.03 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 54 and 79 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of $271.83 (Table

16), with a NPW of $268.46 per acre (Table 12). This financially optimal rotation would produce an estimated 2,811.13 cubic feet of pulpwood and 11.55 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.29 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 54 and 76 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $43.73 (Table 16), with a NPW of $43.67 per acre (Table 12). This financially optimal rotation would produce an estimated 2,991.12 cubic feet of pulpwood and 10.49 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 22.77 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 54 and 76 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$80.12 (Table 16), with a NPW of -$80.10 per acre (Table 12). This financially optimal rotation would produce an estimated 2,991.12 cubic feet of pulpwood and 10.49 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 22.77 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 83 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$156.89 (Table 16), with a NPW of -$156.89 per acre (Table 12). This financially optimal rotation would produce an estimated 2,398.71 cubic feet of pulpwood and 9.08 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 18.54 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 83 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$208.20 (Table 16), with a NPW of -$208.20 per acre (Table 12). This financially optimal rotation would produce an estimated 2,337.94 cubic feet of pulpwood and 8.85 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 18.08 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 65 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 8). This optimal management regime will generate the maximum SEV of $1,219.29 (Table 16), with a NPW of $1,069.81 per acre (Table 12). This financially optimal rotation

would produce an estimated 2,989.17 cubic feet of pulpwood and 16.30 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 27.87 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 48 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 8). This optimal management regime will generate the maximum SEV of $464.60 (Table 16), with a NPW of $455.67 per acre (Table 12). This financially optimal rotation would produce an estimated 2,668.83 cubic feet of pulpwood and 11.21 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.25 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 48 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 8). This optimal management regime will generate the maximum SEV of $188.25 (Table 16), with a NPW of $187.71 per acre (Table 12). This financially optimal rotation would produce an estimated 2,668.83 cubic feet of pulpwood and 11.21 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.25 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 50 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 8). This optimal management regime will generate the maximum SEV of $34.16 (Table 16), with a NPW of $34.15 per acre (Table 12). This financially optimal rotation would produce an estimated 2,714.30 cubic feet of pulpwood and 11.41 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.29 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$62.83 (Table 16), with a NPW of -$62.83 per acre (Table 12). This financially optimal rotation would produce an estimated 2,445.62 cubic feet of pulpwood and 13.13 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 22.89 net tons of carbon per acre during one rotation (Table 4).

Paper birch, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$128.35 (Table 16), with a NPW of -$128.35 per acre (Table 12). This financially optimal rotation would

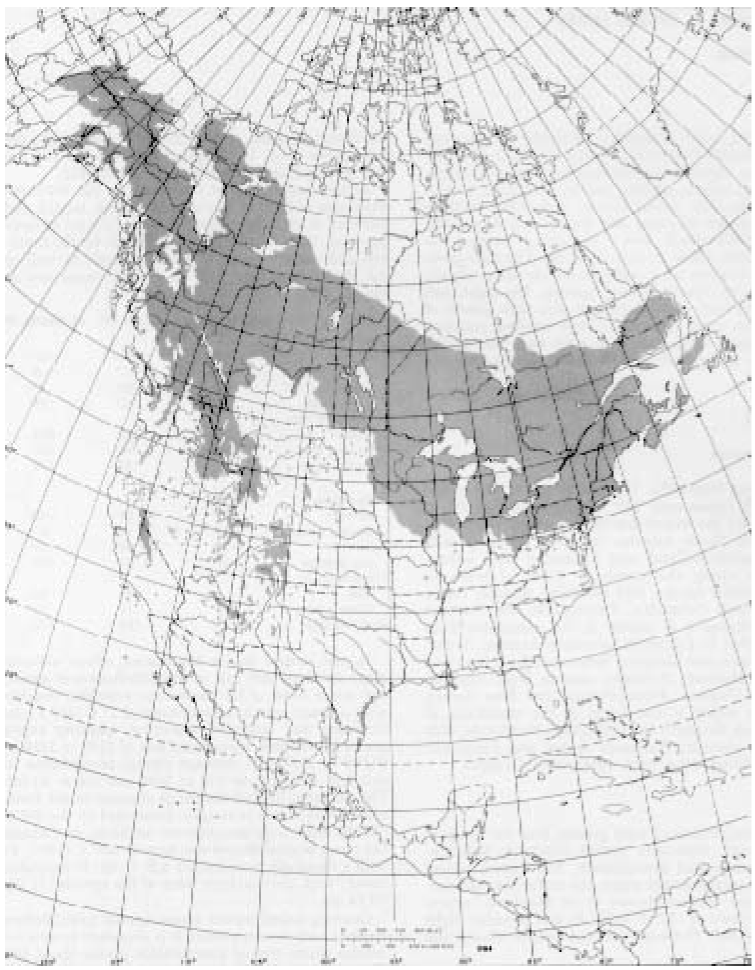
produce an estimated 2,445.62 cubic feet of pulpwood and 13.13 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 22.89 net tons of carbon per acre during one rotation (Table 4).

Literature Review

Quaking Aspen (*Populus tremuloides*)

Biological Information

Quaking aspen is the most widely distributed tree in North America. Mature aspen generally reaches 66 to 82 feet in height, with a d.b.h. from 7 to 12 inches. The native range extends across Canada, the Northeastern United States, and southward through the Rocky Mountains. (Perala 2004).



- The native range of quaking aspen

Aspen occurs where annual precipitation exceeds evapotranspiration, and is limited first to areas of water surplus (Perala 2004). Natural stands grow in a wide variety of soil types ranging from shallow and rocky to deep loamy sands. The best aspen sites are generally found on soils with silt-plus-clay content of 80 percent or more (Perala 2004).

Across its range aspen is a major component of three forest cover types, Aspen (Eastern Forest), Aspen (Western Forest), and White Spruce-Aspen (Type 251). It is a minor component in thirty five other forest cover types, and is an occasional to rare component in three types (Perala 2004). In the Lake States it is often found in association with jack pine (*Pinus banksiana*), red pine (*Pinus resinosa*) , and bigtooth aspen (*P. grandidentata*) (Rudolf 2004).

In nature quaking aspen stands generally become established following fire, which removes the overstory and stimulates vegetative reproduction. Aspen is typically a small to medium sized, fast-growing, and short-lived tree. Site quality varies greatly across its range, being highest in the Lake States. Site indices in quaking aspen range from 40 to 90 feet on a base age 50 curve (Wooden et al. 1996). Aspen is highly intolerant of competition and grows best in even-aged groups or stands. Natural pruning is excellent, and if side shade is maintained, clean stems are usually produced. Individual trees have a pronounced ability to express dominance, and overstocking to stagnation of growth is extremely rare (Perala 2004).

Economic Background

Quaking aspen occupies approximately 30 percent of the commercial forest land in the Lake States (Lamb 1967). Aspen are an important source of pulpwood in the Lakes states, where it contributed 51 percent of the pulpwood harvested in the early 1990’s. Aspen has been used for over 20 years in the multi-billion-dollar Canadian pulp and construction board industry (Johnson 2004).

Aspen is used for a wide variety of products. These products include, lumber, posts, siding, mine props, excelsior, and paper (Johnson 2004). Other uses include matches, novelties, toys, core stock, containers, furniture components, and interior trim (Lamb 1967). No data were found indicating types or amounts of exports of aspen, however due to the size and scope of the pulp and paper industry in Canada it would be reasonable to assume that some aspen timber must be shipped there.

Optimal management of quaking aspen indicates that rotation lengths should be between 30 and 60 years, depending upon site quality. The site index range for aspen in the Lake States for base age 50 trees is 40 to 90 feet (Carmean and Vasilevsky 1971). On good sites maximum development (The point at which the stand should be removed or deterioration begins) should be reached at about age 50 to 60 years, on poor sites at 30 to 50 years (Wooden et al. 1996). Aspen is ready for harvest for whole-tree chip material in 30 to 35 years, or for pulpwood and sawlogs in 40 to 60 years (Kidd and Koelling 1988). Site preparation for aspen generally involves removing all trees greater than two inches in diameter. The understory may also need to be controlled; this could be accomplished through a light prescribed burn (Wooden et al. 1996). Planting is typically not done in aspen stands, as aspen sprouts so vigorously. In general, aspen stands logged in the winter and fall result in more and more vigorous sprouts (Wooden et al 1996). Initial sucker densities can vary widely, with a range from 4,046 to 40,468 stems per acre. Within 8 to 10 years however the stands will have self thinned to 2,023 to 4,046 stems per acre (David et al. 2001). First thinnings in aspen stands are generally conducted between 25 and 35 years of age, but only in areas with a site index of 70 or better. The recommended procedure is to remove all trees except for 200-300 crop trees per acre

(Wooden et al. 1996). Nowhere in the literature could a reference be found recommending more than one thinning operation, possibly because of root sprouting when stem density falls too low.

Dry weight equations for quaking aspen are as follows: Ln (bole wood + bark) =0.99889(Ln BH)+2.5006 (Schlaegel 1975).

Where:

Ln = natural log
B = basal area (ft^2)
H = total height from a 6 inch stump (ft)

Information was not found concerning number of mills or mill production in the area of interest. Minimum cutting volumes for aspen were also not found. Some of this information may yet be found in the literature, however some may only be found through contacting professionals in the region.

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Species___quaking aspen__________ Region______Lake States_________________

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 4.30, 5.10, and 6.00 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 1 thinning during the rotation. The first thinning could not be conducted until the stand was at least 25 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 200 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183553598 and 0.489476260, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Schlaegel (1975) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$\mathrm{Ln(bole\ wood+bark)} = 0.99889(\mathrm{LnBH})+2.5006$$

where:

bole wood + bark = weight in pounds

B = basal area (ft^2.)

H = total height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisors 200X). The price of sawtimber was assumed to be \$79/mbf (International 1/4) (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005) and pulpwood price was assumed to be \$27.50/cord (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005). The price of carbon was assumed to be \$0, \$10, \$37 or \$50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of quaking aspen plantations in the Lake States.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$218.00	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]The seedling cost was estimated based on the seedling prices from Lee's Nursery, Inc. (http://www.leenursery.com/Seedling2006Catalog.pdf. January 18, 2006)

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Table 1. Total tons of carbon sequestered per acre for quaking aspen plantations in the lake states United States by site index and real alternative rates of return. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	16.90	16.85	16.81	16.68	16.39	16.39
80	19.64	18.74	18.74	18.74	18.74	18.67
90	21.54	21.30	21.21	21.02	21.02	21.08

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for quaking aspen plantations in the lake states United States by site index and real alternative rates of return. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	17.00	16.85	16.85	16.81	16.68	16.68
80	19.81	19.41	18.74	18.74	18.74	18.74
90	22.38	21.54	21.30	21.21	21.02	21.02

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for quaking aspen plantations in the lakes states United States by site index and real alternative rates of return. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	17.43	17.43	17.56	17.56	17.59	17.59
80	19.81	19.81	19.81	19.81	19.81	19.81
90	22.33	22.48	22.48	22.48	22.48	22.48

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for quaking aspen plantations in the lake states United States by site index and real alternative rates of return. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	17.43	17.56	17.59	17.59	17.59	16.95
80	19.81	19.81	19.85	19.85	19.89	19.89
90	22.33	22.48	22.48	22.48	22.53	22.53

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for quaking aspen plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	<29-**54**[2]> (30%)	<29-**53**> (30%)[3]	<29-**52**>[4] (30%)	<29-**51**> (30%)	<29-**50**> (30%)	<29-**50**> (30%)
80	<31-**57> (30%)**	<26-**49**> (30%)	<26-**49**> (30%)	<26-**49**> (30%)	<26-**49**> (30%)	<26-**48**> (30%)
90	<27-**51**> (30%)	<26-**49**> (30%)	<26-**47**> (30%)	<26-**46**> (30%)	<26-**46**> (30%)	<25-**46**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for quaking aspen plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	<30-**54**[2]> (30%)[3]	<29-**53**>[4] (30%)	<29-**53**> (30%)	<29-**52**> (30%)	<29-**51**> (30%)	<29-**51**> (30%)
80	32-**57** (30%)	<31-**51**> (30%)	<26-**49**> (30%)	<26-**49**> (30%)	<26-**49**> (30%)	<26-**49**> (30%)
90	34-**52** (30%)	<27-**51**> (30%)	<26-**49**> (30%)	<26-**47**> (30%)	<26-**46**> (30%)	<26-**46**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for quaking aspen plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	34-**55**[2] (30%)[3]	34-**55** (30%)	<34-**59**>[4] (30%)	<34-**59**> (30%)	<34-**60**> (30%)	<34-**60**> (30%)
80	32-**57** (30%)	32-**57** (30%)	<32-**57**> (30%)	<32-**57**> (30%)	<32-**58**> (30%)	<32-**58**> (30%)
90	33-**52** (30%)	31-**59** (30%)	<31-**59**> (30%)	<31-**59**> (30%)	<31-**59**> (30%)	<31-**59**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for quaking aspen plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	34-**55**[2] (30%)[3]	34-**59** (30%)	<34-**60**>[4] (30%)	<34-**60**> (30%)	<34-**60**> (30%)	<34-**60**> (30%)
80	32-**57** (30%)	32-**57** (30%)	32-**59** (30%)	<32-**59**> (30%)	<32-**60**> (30%)	<32-**60**> (30%)
90	33-**52** (30%)	31-**59** (30%)	31-**59** (30%)	<31-**59**> (30%)	<31-**60**> (30%)	<31-**60**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for quaking aspen plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-171.80	-375.64	-434.73	-453.23	-459.42	-461.54
80	-128.36	-352.31	-424.61	-448.84	-457.34	-460.33
90	-73.56	-336.13	-416.15	-444.27	-455.16	-459.35

[1]Base age 50.

Table10. Net present worth of the financially optimal thinning and final harvest schedules for quaking aspen plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-21.81	-266.18	-356.29	-395.37	-415.57	-427.49
80	54.14	-228.65	-333.29	-380.85	-405.58	-420.09
90	127.51	-191.38	-310.94	-365.19	-394.26	-411.69

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for quaking aspen plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	395.94	36.95	-139.32	-236.49	-295.9	-334.87
80	549.05	128.55	-77.78	-192.82	-263.44	-309.88
90	674.49	224.36	-12.24	-145.03	-227.14	-281.53

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for quaking aspen plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	597.34	187.34	-31.92	-158.46	-237.45	-289.87
80	787.34	303.99	48.40	-100.66	-194.14	-256.36
90	937.93	430.79	136.09	-36.37	-145.27	-218.15

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for quaking aspen plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-231.28	-404.68	-444.35	-456.45	460.56	-461.91
80	-168.62	-385.97	-436.34	-452.70	-458.61	-460.82
90	-101.73	-368.24	-429.50	-449.36	-456.96	-460.00

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for quaking aspen plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-29.36	-286.75	-363.61	-397.92	-416.48	-427.79
80	71.12	-248.29	-342.50	-384.12	-406.71	-420.48
90	174.71	-207.81	-319.53	-368.99	-395.83	-412.27

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for quaking aspen plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	528.54	39.52	-141.16	-237.27	-296.12	-334.94
80	721.28	136.61	-78.97	-193.59	-263.70	-309.96
90	924.17	237.05	-12.40	-145.51	-227.33	-281.59

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for quaking aspen plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	797.39	197.94	-32.31	-162.63	-237.63	-289.93
80	1,034.33	323.06	49.04	-100.99	-194.29	-256.41
90	1,285.13	455.16	137.89	-36.49	-145.38	-218.19

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for quaking aspen plantations by soil productivity and real alternative rates of return in the lake states United States. (carbon value = $0/ton)

Site Index[1]	ARR	Schedule	1st thinning		2nd thinning		Final Harvest		Total Volume	
			Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	29-**54**[3] (30%)[4]	607.67	0	-[5]	-	1,923.26	7.77	2,530.93	7.77
	5.00%	29-**53** (30%)	607.67	0	-	-	2,032.78	7.24	2,640.45	7.24
	7.50%	29-**52** (30%)	607.67	0	-	-	2,227.82	6.37	2,835.49	6.37
	10.00%	29-**51** (30%)	607.67	0	-	-	2,388.11	5.51	2,995.78	5.51
	12.50%	29-**50** (30%)	607.67	0	-	-	2,504.38	4.57	3,112.05	4.57
	15.00%	29-**50** (30%)	607.67	0	-	-	2,504.38	4.57	3,112.05	4.57
80	2.50%	31-**57** (30%)	773.85	0	-	-	1,713.95	10.79	2,487.80	10.79
	5.00%	26-**49** (30%)	561.56	0	-	-	2,210.93	7.50	2,772.49	7.50
	7.50%	26-**49** (30%)	561.56	0	-	-	2,210.93	7.50	2,772.49	7.50
	10.00%	26-**49** (30%)	561.56	0	-	-	2,210.93	7.50	2,772.49	7.50
	12.50%	26-**49** (30%)	561.56	0	-	-	2,210.93	7.50	2,772.49	7.50
	15.00%	26-**48** (30%)	561.56	0	-	-	2,379.97	6.21	2,941.53	6.21
90	2.50%	27-**51** (30%)	704.19	0	-	-	2,083.58	10.36	2,787.77	10.36
	5.00%	26-**49** (30%)	663.83	0	-	-	2,332.85	8.68	2,996.68	8.68
	7.50%	26-**47** (30%)	663.83	0	-	-	2,335.48	7.55	2,999.31	7.55
	10.00%	26-**46** (30%)	663.83	0	-	-	2,435.79	6.74	3,099.62	6.74
	12.50%	26-**46** (30%)	663.83	0	-	-	2,435.79	6.74	3,099.62	6.74
	15.00%	25-**46** (30%)	572.41	0	-	-	2,402.85	7.05	2,975.26	7.05

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 18. Volume removed from the financially optimal schedules for quaking aspen plantations by soil productivity and real alternative rates of return in the lake states United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	30-**54**[3] (30%)[4]	628.21	0	-[5]	-	1,944.32	7.66	2,572.53	7.66
	5.00%	29-**53** (30%)	607.67	0	-	-	2,032.78	7.24	2,604.45	7.24
	7.50%	29-**53** (30%)	607.67	0	-	-	2,032.78	7.24	2,604.45	7.24
	10.00%	29-**52** (30%)	607.67	0	-	-	2,227.82	6.37	2,835.49	6.37
	12.50%	29-**51** (30%)	607.67	0	-	-	2,388.11	5.51	2,995.78	5.51
	15.00%	29-**51** (30%)	607.67	0	-	-	2,388.11	5.51	2,995.78	5.51
80	2.50%	32-**57** (30%)	812.03	0	-	-	1,762.09	10.54	2,574.12	10.54
	5.00%	31-**51** (30%)	773.85	0	-	-	2,235.74	7.68	3,009.59	7.68
	7.50%	26-**49** (30%)	561.56	0	-	-	2,210.93	7.50	2,772.49	7.50
	10.00%	26-**49** (30%)	561.56	0	-	-	2,210.93	7.50	2,772.49	7.50
	12.50%	26-**49** (30%)	561.56	0	-	-	2,210.93	7.50	2,772.49	7.50
	15.00%	26-**49** (30%)	561.56	0	-	-	2,210.93	7.50	2,772.49	7.50
90	2.50%	34-**52** (30%)	939.90	0	-	-	2,105.56	10.22	3,045.46	10.22
	5.00%	27-**51** (30%)	704.19	0	-	-	2,083.58	10.36	2,787.75	10.36
	7.50%	26-**49** (30%)	663.83	0	-	-	2,332.85	8.68	2,996.68	8.68
	10.00%	26-**47** (30%)	663.83	0	-	-	2,335.49	7.55	2,999.32	7.55
	12.50%	26-**46** (30%)	663.83	0	-	-	2,435.79	6.74	3,099.62	6.74
	15.00%	26-**46** (30%)	663.83	0	-	-	2,435.79	6.74	3,099.62	6.74

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for quaking aspen plantations by soil productivity and real alternative rates of return in the lake states United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	34-**55**[3] (30%)[4]	706.52	0	-[5]	-	1,943.86	7.67	2,650.38	7.67
	5.00%	34-**55** (30%)	706.52	0	-	-	1,943.86	7.67	2,650.38	7.67
	7.50%	34-**59** (30%)	706.52	0	-	-	1,853.30	8.31	2,559.82	8.31
	10.00%	34-**59** (30%)	706.52	0	-	-	1,853.30	8.31	2,559.82	8.31
	12.50%	34-**60** (30%)	706.52	0	-	-	1,779.21	8.71	2,485.73	8.71
	15.00%	34-**60** (30%)	706.52	0	-	-	1,779.21	8.71	2,485.73	8.71
80	2.50%	32-**57** (30%)	812.03	0	-	-	1,762.09	10.54	2,574.12	10.54
	5.00%	32-**57** (30%)	812.03	0	-	-	1,762.09	10.54	2,574.12	10.54
	7.50%	32-**57** (30%)	812.03	0	-	-	1,762.09	10.54	2,574.12	10.54
	10.00%	32-**57** (30%)	812.03	0	-	-	1,762.09	10.54	2,574.12	10.54
	12.50%	32-**58** (30%)	812.03	0	-	-	1,713.25	10.83	2,525.28	10.83
	15.00%	32-**58** (30%)	812.03	0	-	-	1,713.25	10.83	2,525.28	10.83
90	2.50%	33-**52** (30%)	914.18	0	-	-	2,103.98	10.22	3,018.16	10.22
	5.00%	31-**59** (30%)	813.75	0	-	-	1,533.90	13.88	2,347.65	13.88
	7.50%	31-**59** (30%)	813.75	0	-	-	1,533.90	13.88	2,347.65	13.88
	10.00%	31-**59** (30%)	813.75	0	-	-	1,533.90	13.88	2,347.65	13.88
	12.50%	31-**59** (30%)	813.75	0	-	-	1,533.90	13.88	2,347.65	13.88
	15.00%	31-**59** (30%)	813.75	0	-	-	1,533.90	13.88	2,347.65	13.88

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for quaking aspen plantations by soil productivity and real alternative rates of return in the lake states United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	34-**55**[3] (30%)[4]	706.52	0	-[5]	-	1,943.86	7.67	2,650.38	7.67
	5.00%	34-**59** (30%)	706.52	0	-	-	1,853.30	8.31	2,559.82	8.31
	7.50%	34-**60** (30%)	706.52	0	-	-	1,779.21	8.71	2,485.73	8.71
	10.00%	34-**60** (30%)	706.52	0	-	-	1,779.21	8.71	2,485.73	8.71
	12.50%	34-**60** (30%)	706.52	0	-	-	1,779.21	8.71	2,485.73	8.71
	15.00%	34-**60** (30%)	706.52	0	-	-	1,779.21	8.71	2,485.73	8.71
80	2.50%	32-**57** (30%)	812.03	0	-	-	1,762.09	10.54	2,574.12	10.54
	5.00%	32-**57** (30%)	812.03	0	-	-	1,762.09	10.54	2,574.12	10.54
	7.50%	32-**59** (30%)	812.03	0	-	-	1,714.93	10.91	2,526.96	10.91
	10.00%	32-**59** (30%)	812.03	0	-	-	1,714.93	10.91	2,526.96	10.91
	12.50%	32-**60** (30%)	812.03	0	-	-	1,716.41	10.98	2,528.44	10.98
	15.00%	32-**60** (30%)	812.03	0	-	-	1,716.41	10.98	2,528.44	10.98
90	2.50%	33-**52** (30%)	914.18	0	-	-	2,103.98	10.22	3,018.16	10.22
	5.00%	31-**59** (30%)	813.75	0	-	-	1,533.90	13.88	2,347.65	13.88
	7.50%	31-**59** (30%)	813.75	0	-	-	1,533.90	13.88	2,347.65	13.88
	10.00%	31-**59** (30%)	813.75	0	-	-	1,533.90	13.88	2,347.65	13.88
	12.50%	31-**60** (30%)	813.75	0	-	-	1,537.04	14.00	2,350.79	14.00
	15.0%	31-**60** (30%)	813.75	0	-	-	1,537.04	14.00	2,350.79	14.00

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for quaking aspen plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	<29-**54**[2]>[3] (30%)[4]	<30-**54**> (30%)	0%	34-**55** (30%)	2%	34-**55** (30%)	2%
	80	<31-**57**> (30%)	32-**57** (30%)	0%	32-**57** (30%)	0%	32-**57** (30%)	0%
	90	<27-**51**> (30%)	34-**52** (30%)	2%	33-**52** (30%)	2%	33-**52** (30%)	2%
5.00%	70	<29-**53**> (30%)[3]	<29-**53**> (30%)	0%	34-**55** (30%)	4%	34-**59** (30%)	11%
	80	<26-**49**> (30%)	<31-**51**> (30%)	4%	32-**57** (30%)	16%	32-**57** (30%)	16%
	90	<26-**49**> (30%)	<27-**51**> (30%)	4%	31-**59** (30%)	20%	31-**59** (30%)	20%
7.50%	70	<29-**52**> (30%)	<29-**53**> (30%)	2%	<34-**59**> (30%)	13%	<34-**60**> (30%)	15%
	80	<26-**49**> (30%)	<26-**49**> (30%)	0%	<32-**57**> (30%)	16%	32-**59** (30%)	20%
	90	<26-**47**> (30%)	<26-**49**> (30%)	4%	<31-**59**> (30%)	26%	31-**59** (30%)	26%
10.00%	70	<29-**51**> (30%)	<29-**52**> (30%)	2%	<34-**59**> (30%)	16%	<34-**60**> (30%)	18%
	80	<26-**49**> (30%)	<26-**49**> (30%)	0%	<32-**57**> (30%)	16%	<32-**59**> (30%)	20%
	90	<26-**46**> (30%)	<26-**47**> (30%)	2%	<31-**59**> (30%)	28%	<31-**59**> (30%)	28%
12.50%	70	<29-**50**> (30%)	<29-**51**> (30%)	2%	<34-**60**> (30%)	20%	<34-**60**> (30%)	20%
	80	<26-**49**> (30%)	<26-**49**> (30%)	0%	<32-**58**> (30%)	18%	<32-**60**> (30%)	22%
	90	<26-**46**> (30%)	<26-**46**> (30%)	0%	<31-**59**> (30%)	28%	<31-**60**> (30%)	30%
15.00%	70	<29-**50**> (30%)	<29-**51**> (30%)	2%	<34-**60**> (30%)	20%	<34-**60**> (30%)	20%
	80	<26-**48**> (30%)	<26-**49**> (30%)	2%	<32-**58**> (30%)	21%	<32-**60**> (30%)	25%
	90	<25-**46**> (30%)	<26-**46**> (30%)	0%	<31-**59**> (30%)	28%	<31-**60**> (30%)	30%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning.

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for quaking aspen plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	-231.28	-29.36		528.54		797.39	
	80	-168.62	71.12		721.28		1,034.33	
	90	-101.73	174.71		924.17		1,285.13	
5.00%	70	-404.68	-286.75		39.52		197.94	
	80	-385.97	-248.29		136.61		323.06	
	90	-368.24	-207.81		237.05		455.16	
7.50%	70	-444.35	-363.61		-141.16		-32.31	
	80	-436.34	-342.50		-78.97		49.04	
	90	-429.50	-319.53		-12.40		137.89	
10.00%	70	-456.45	-397.92		-237.27		-162.63	
	80	-452.70	-384.12		-193.59		-100.99	
	90	-449.36	-368.99		-145.51		-36.49	
12.50%	70	-460.56	-416.48		-296.12		-237.63	
	80	-458.61	-406.71		-263.70		-194.29	
	90	-456.96	-395.83		-227.33		-145.38	
15.00%	70	-461.91	-427.79		-334.94		-289.93	
	80	-460.82	-420.48		-309.96		-256.41	
	90	-460.00	-412.27		-281.59		-218.19	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

Lake States- Quaking aspen - Timber Only Rotations (C = $0/ton)

Quaking aspen, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 29 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 5). This optimal management regime will generate the maximum SEV of -$231.28 (Table 13), with a NPW of -$171.80 per acre (Table 9). This means that -$231.28 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$171.80 per acre for managing one rotation, or -$231.28 per acre from managing an infinite number of rotations. This financially optimal rotation could produce an estimated 2,530.93 cubic feet of pulpwood and 7.77 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 16.90 tons of carbon per acre during the rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Quaking aspen, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 29 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 53 (Table 5). This optimal management regime will generate the maximum SEV of -$404.68 (Table 13), with a NPW of -$375.64 per acre (Table 9). This financially optimal rotation could produce an estimated 2,640.45 cubic feet of pulpwood and 7.24 MBF of sawlog per acre

from the thinning and final harvest (Table 17), and sequester 16.85 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 29 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 5). This optimal management regime will generate the maximum SEV of -$444.35 (Table 13), with a NPW of -$434.73 per acre (Table 9). This financially optimal rotation could produce an estimated 2,835.49 cubic feet of pulpwood and 6.37 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 16.81 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 29 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 5). This optimal management regime will generate the maximum SEV of -$456.45 (Table 13), with a NPW of -$453.23 per acre (Table 9). This financially optimal rotation could produce an estimated 2,995.78 cubic feet of pulpwood and 5.51 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 16.68 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 29 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 50 (Table 5). This optimal management regime will generate the maximum SEV of -$460.56 (Table 13), with a NPW of -$459.42 per acre (Table 9). This financially optimal rotation could produce an estimated 3,112.05 cubic feet of pulpwood and 4.57 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 16.39 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 29 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 50 (Table 5). This optimal management regime will generate the maximum SEV of -$461.91 (Table 13), with a NPW of -$461.54 per acre (Table 9). This financially optimal rotation could produce an estimated 3,112.05 cubic feet of pulpwood and 4.57 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 16.39 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 5). This optimal management regime will generate the maximum SEV of -$168.62 (Table 13), with a NPW of -$128.36 per acre (Table 9). This financially optimal rotation could produce an estimated 2,487.80 cubic feet of pulpwood and 10.79 MBF of sawlog per acre

from the thinning and final harvest (Table 17), and sequester 19.64 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 5). This optimal management regime will generate the maximum SEV of -$385.97 (Table 13), with a NPW of -$352.31 per acre (Table 9). This financially optimal rotation could produce an estimated 2,772.49 cubic feet of pulpwood and 7.50 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 18.74 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 5). This optimal management regime will generate the maximum SEV of -$436.34 (Table 13), with a NPW of -$424.61 per acre (Table 9). This financially optimal rotation could produce an estimated 2,772.49 cubic feet of pulpwood and 7.50 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 18.74 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 49 (Table 5). This optimal management regime will generate the maximum SEV of -$452.70 (Table 13), with a NPW of -$448.84 per acre (Table 9). This financially optimal rotation could produce an estimated 2,772.49 cubic feet of pulpwood and 7.50 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 18.74 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 5). This optimal management regime will generate the maximum SEV of -$458.61 (Table 13), with a NPW of -$457.34 per acre (Table 9). This financially optimal rotation could produce an estimated 2,772.49 cubic feet of pulpwood and 7.50 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 18.74 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 48 (Table 5). This optimal management regime will generate the maximum SEV of -$460.82 (Table 13), with a NPW of -$460.33 per acre (Table 9). This financially optimal rotation could produce an estimated 2,772.49 cubic feet of pulpwood and 7.50 MBF of sawlog per acre

from the thinning and final harvest (Table 17), and sequester 18.74 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 5). This optimal management regime will generate the maximum SEV of -$101.73 (Table 13), with a NPW of -$73.56 per acre (Table 9). This financially optimal rotation could produce an estimated 2,778.77 cubic feet of pulpwood and 10.36 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 21.54 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 5). This optimal management regime will generate the maximum SEV of -$368.24 (Table 13), with a NPW of -$336.13 per acre (Table 9). This financially optimal rotation could produce an estimated 2,996.68 cubic feet of pulpwood and 8.68 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 21.30 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 47 (Table 5). This optimal management regime will generate the maximum SEV of -$429.50 (Table 13), with a NPW of -$416.15 per acre (Table 9). This financially optimal rotation could produce an estimated 2,999.31 cubic feet of pulpwood and 7.55 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 21.21 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 5). This optimal management regime will generate the maximum SEV of -$449.36 (Table 13), with a NPW of -$444.27 per acre (Table 9). This financially optimal rotation could produce an estimated 3,099.62 cubic feet of pulpwood and 6.74 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 21.02 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 5). This optimal management regime will generate the maximum SEV of -$456.96 (Table 13), with a NPW of -$455.16 per acre (Table 9). This financially optimal rotation could produce an estimated 3,099.62 cubic feet of pulpwood and 6.74 MBF of sawlog per acre

from the thinning and final harvest (Table 17), and sequester 21.02 tons of carbon per acre during the rotation (Table 1).

Quaking aspen, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 5). This optimal management regime will generate the maximum SEV of -$460.00 (Table 13), with a NPW of -$459.35 per acre (Table 9). This financially optimal rotation could produce an estimated 3,099.62 cubic feet of pulpwood and 6.74 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 21.02 tons of carbon per acre during the rotation (Table 1).

Lake States- Quaking aspen - Timber Plus Carbon Rotations (C = $10/ton)

Quaking aspen, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 30 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 6). This optimal management regime will generate the maximum SEV of -$29.36 (Table 14), with a NPW of -$21.81 per acre (Table 10). This means that -$29.36 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$21.81 per acre for managing one rotation, or -$29.36 per acre from managing an infinite number of rotations. This financially optimal rotation could produce an estimated 2,572.53 cubic feet of pulpwood and 7.66 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 17.00 tons of carbon per acre during the rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Quaking aspen, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 29 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 53 (Table 6). This optimal management regime will generate the maximum SEV of -$286.75 (Table 14), with a NPW of -$266.18 per acre (Table 10). This financially optimal rotation could produce an estimated 2,604.45 cubic feet of pulpwood and 7.24 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 16.85 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 29 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 53 (Table 6). This optimal management regime will generate the maximum SEV of -$363.61 (Table 14), with a NPW of -$356.29 per acre (Table 10). This financially optimal rotation could produce an estimated 2,604.45 cubic feet of pulpwood and 7.24 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 16.85 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 29 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 6). This optimal management regime will generate the maximum SEV of -$397.92 (Table 14), with a NPW of -$395.37 per acre (Table 10). This financially optimal rotation could produce an estimated 2,835.49 cubic feet of pulpwood and 6.37 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 16.81 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 29 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 6). This optimal management regime will generate the maximum SEV of -$416.48 (Table 14), with a NPW of -$415.57 per acre (Table 10). This financially optimal rotation could produce an estimated 2,995.78 cubic feet of pulpwood and 5.51 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 16.68 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 29 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 6). This optimal management regime will generate the maximum SEV of -$427.79 (Table 14),

with a NPW of -$427.49 per acre (Table 10). This financially optimal rotation could produce an estimated 2,995.78 cubic feet of pulpwood and 5.51 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 16.68 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 6). This optimal management regime will generate the maximum SEV of $71.12 (Table 14), with a NPW of $54.14 per acre (Table 10). This financially optimal rotation could produce an estimated 2,574.12 cubic feet of pulpwood and 10.54 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 19.81 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 6). This optimal management regime will generate the maximum SEV of -$248.29 (Table 14), with a NPW of -$228.65 per acre (Table 10). This financially optimal rotation could produce an estimated 3,009.59 cubic feet of pulpwood and 7.68 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 19.41 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 6). This optimal management regime will generate the maximum SEV of -$342.50 (Table 14), with a NPW of -$333.29 per acre (Table 10). This financially optimal rotation could produce an estimated 2,772.49 cubic feet of pulpwood and 7.50 MBF of sawlog per acre from the thinning and final harvest (Table18), and sequester 18.74 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 6). This optimal management regime will generate the maximum SEV of -$384.12 (Table 14), with a NPW of -$380.85 per acre (Table 10). This financially optimal rotation could produce an estimated 2,772.49 cubic feet of pulpwood and 7.50 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 18.74 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 6). This optimal management regime will generate the maximum SEV of -$406.71 (Table 14), with a NPW of -$405.58 per acre (Table 10). This financially optimal rotation could

produce an estimated 2,772.49 cubic feet of pulpwood and 7.50 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 18.74 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 6). This optimal management regime will generate the maximum SEV of -$420.48 (Table 14), with a NPW of -$420.09 per acre (Table 10). This financially optimal rotation could produce an estimated 2,772.49 cubic feet of pulpwood and 7.50 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 18.74 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 6). This optimal management regime will generate the maximum SEV of $174.71 (Table 14), with a NPW of $127.51 per acre (Table 10). This financially optimal rotation could produce an estimated 3,045.46 cubic feet of pulpwood and 10.22 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 22.38 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 6). This optimal management regime will generate the maximum SEV of -$207.81 (Table 14), with a NPW of -$191.38 per acre (Table 10). This financially optimal rotation could produce an estimated 2,787.75 cubic feet of pulpwood and 10.36 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 21.54 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 6). This optimal management regime will generate the maximum SEV of -$319.53 (Table 14), with a NPW of -$310.94 per acre (Table 10). This financially optimal rotation could produce an estimated 2,996.68 cubic feet of pulpwood and 8.68 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 21.30 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 47 (Table 6). This optimal management regime will generate the maximum SEV of -$368.99 (Table 14), with a NPW of -$365.19 per acre (Table 10). This financially optimal rotation could

produce an estimated 2,999.32 cubic feet of pulpwood and 7.55 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 21.21 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 6). This optimal management regime will generate the maximum SEV of -$395.83 (Table 14), with a NPW of -$394.26 per acre (Table 10). This financially optimal rotation could produce an estimated 3,099.62 cubic feet of pulpwood and 6.74 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 21.02 tons of carbon per acre during the rotation (Table 2).

Quaking aspen, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 6). This optimal management regime will generate the maximum SEV of -$412.27 (Table 14), with a NPW of -$411.69 per acre (Table 10). This financially optimal rotation could produce an estimated 3,099.62 cubic feet of pulpwood and 6.74 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 21.02 tons of carbon per acre during the rotation (Table 2).

<u>Lake States- Quaking aspen - Timber Plus Carbon Rotations (C = $37/ton)</u>

Quaking aspen, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 7). This optimal management regime will generate the maximum SEV of $528.54 (Table 15), with a NPW of $395.94 per acre (Table 11). This means that $528.54 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $395.94 per acre for managing one rotation, or $528.54 per acre from managing an infinite number of rotations. This financially optimal rotation could produce an estimated 2,650.38 cubic feet of pulpwood and 7.67 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 17.43 tons of carbon per acre during the rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Quaking aspen, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 7). This optimal management regime will generate the maximum SEV of $39.52 (Table 15), with a NPW of $36.95 per acre (Table 11). This financially optimal rotation could produce an estimated 2,650.38 cubic feet of pulpwood and 7.67 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 17.43 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 7). This optimal management regime will generate the maximum SEV of -$141.16 (Table 15), with a NPW of $139.32 per acre (Table 11). This financially optimal rotation could produce an estimated 2,559.82 cubic feet of pulpwood and 8.31 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 17.56 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 7). This optimal management regime will generate the maximum SEV of -$237.27 (Table 15), with a NPW of -$236.49 per acre (Table 11). This financially optimal rotation could produce an estimated 2,559.82 cubic feet of pulpwood and 8.31 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 17.56 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$296.12 (Table 15), with a NPW of -$295.90 per acre (Table 11). This financially optimal rotation could produce an estimated 2,485.73 cubic feet of pulpwood and 8.71 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 17.59 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$334.94 (Table 15), with a NPW of -$334.87 per acre (Table 11). This financially optimal rotation could produce an estimated 2,485.73 cubic feet of pulpwood and 8.71 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 17.59 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 7). This optimal management regime will generate the maximum SEV of $721.28 (Table 15), with a NPW of $549.05 per acre (Table 11). This financially optimal rotation could produce an estimated 2,574.12 cubic feet of pulpwood and 10.54 MBF of sawlog per acre

from the thinning and final harvest (Table 19), and sequester 19.81 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 7). This optimal management regime will generate the maximum SEV of $136.61 (Table 15), with a NPW of $128.55 per acre (Table 11). This financially optimal rotation could produce an estimated 2,574.12 cubic feet of pulpwood and 10.54 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 19.81 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 7). This optimal management regime will generate the maximum SEV of -$78.97 (Table 15), with a NPW of -$77.78 per acre (Table 11). This financially optimal rotation could produce an estimated 2,574.12 cubic feet of pulpwood and 10.54 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 19.81 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 57 (Table 7). This optimal management regime will generate the maximum SEV of -$193.59 (Table 15), with a NPW of -$192.82 per acre (Table 11). This financially optimal rotation could produce an estimated 2,574.12 cubic feet of pulpwood and 10.54 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 19.81 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 7). This optimal management regime will generate the maximum SEV of -$263.70 (Table 15), with a NPW of -$263.44 per acre (Table 11). This financially optimal rotation could produce an estimated 2,525.28 cubic feet of pulpwood and 10.83 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 19.81 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 7). This optimal management regime will generate the maximum SEV of -$309.96 (Table 15), with a NPW of -$309.88 per acre (Table 11). This financially optimal rotation could produce an estimated 2,525.28 cubic feet of pulpwood and 10.83 MBF of sawlog per acre

from the thinning and final harvest (Table 19), and sequester 19.81 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 33 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 7). This optimal management regime will generate the maximum SEV of $924.17 (Table 15), with a NPW of $674.49 per acre (Table 11). This financially optimal rotation could produce an estimated 3,018.16 cubic feet of pulpwood and 10.22 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 22.33 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 7). This optimal management regime will generate the maximum SEV of $237.05 (Table 15), with a NPW of $224.36 per acre (Table 11). This financially optimal rotation could produce an estimated 2,347.65 cubic feet of pulpwood and 13.88 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 22.48 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 7). This optimal management regime will generate the maximum SEV of -$12.40 (Table 15), with a NPW of -$12.24 per acre (Table 11). This financially optimal rotation could produce an estimated 2,347.36 cubic feet of pulpwood and 10.54 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 22.48 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 7). This optimal management regime will generate the maximum SEV of -$145.51 (Table 15), with a NPW of -$145.03 per acre (Table 11). This financially optimal rotation could produce an estimated 2,347.65 cubic feet of pulpwood and 13.88 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 22.48 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 7). This optimal management regime will generate the maximum SEV of -$227.33 (Table 15), with a NPW of -$227.14 per acre (Table 11). This financially optimal rotation could produce an estimated 2,347.65 cubic feet of pulpwood and 13.88 MBF of sawlog per acre

from the thinning and final harvest (Table 19), and sequester 22.48 tons of carbon per acre during the rotation (Table 3).

Quaking aspen, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 7). This optimal management regime will generate the maximum SEV of -$281.59 (Table 15), with a NPW of -$281.53 per acre (Table 11). This financially optimal rotation could produce an estimated 2,347.65 cubic feet of pulpwood and 13.88 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 22.48 tons of carbon per acre during the rotation (Table 3).

<u>Lake States- Quaking aspen - Timber Plus Carbon Rotations (C = $50/ton)</u>

Quaking aspen, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 8). This optimal management regime will generate the maximum SEV of $797.39 (Table 16), with a NPW of $597.34 per acre (Table 12). This means that $797.39 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $597.34 per acre for managing one rotation, or $797.39 per acre from managing an infinite number of rotations. This financially optimal rotation could produce an estimated 2,650.38 cubic feet of pulpwood and 7.67 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 17.43 tons of carbon per acre during the rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Quaking aspen, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 8). This optimal management regime will generate the maximum SEV of $197.94 (Table 16), with a NPW of $187.34 per acre (Table 12). This financially optimal rotation could produce an estimated 2,559.82 cubic feet of pulpwood and 8.31 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 17.56 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$32.31 (Table 16), with a NPW of -$31.92 per acre (Table 12). This financially optimal rotation could produce an estimated 2,485.73 cubic feet of pulpwood and 8.71 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 17.59 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$162.63 (Table 16), with a NPW of $158.46 per acre (Table 12). This financially optimal rotation could produce an estimated 2,485.73 cubic feet of pulpwood and 8.71 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 17.59 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$237.63 (Table 16), with a NPW of -$237.45 per acre (Table 12). This financially optimal rotation could produce an estimated 2,485.73 cubic feet of pulpwood and 8.71 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 17.59 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$289.93 (Table 16),

with a NPW of -$289.87 per acre (Table 12). This financially optimal rotation could produce an estimated 2,485.73 cubic feet of pulpwood and 8.71 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 16.95 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 8). This optimal management regime will generate the maximum SEV of $1,034.33 (Table 16), with a NPW of $787.34 per acre (Table 12). This financially optimal rotation could produce an estimated 2,574.12 cubic feet of pulpwood and 10.54 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 19.81 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 8). This optimal management regime will generate the maximum SEV of $323.06 (Table 16), with a NPW of $303.99 per acre (Table 12). This financially optimal rotation could produce an estimated 2,574.12 cubic feet of pulpwood and 10.54 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 19.81 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 8). This optimal management regime will generate the maximum SEV of $49.04 (Table 16), with a NPW of $48.40 per acre (Table 12). This financially optimal rotation could produce an estimated 2,526.96 cubic feet of pulpwood and 10.91 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 19.85 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 8). This optimal management regime will generate the maximum SEV of -$100.99 (Table 16), with a NPW of $100.66 per acre (Table 12). This financially optimal rotation could produce an estimated 2,526.96 cubic feet of pulpwood and 10.91 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 19.85 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$194.29 (Table 16), with a NPW of $194.14 per acre (Table 12). This financially optimal rotation could

produce an estimated 2,528.44 cubic feet of pulpwood and 10.98 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 19.89 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$256.41 (Table 16), with a NPW of -$256.36 per acre (Table 12). This financially optimal rotation could produce an estimated 2,528.44 cubic feet of pulpwood and 10.98 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 19.89 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 33 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 8). This optimal management regime will generate the maximum SEV of $1,285.13 (Table 16), with a NPW of $937.93 per acre (Table 12). This financially optimal rotation could produce an estimated 3,018.16 cubic feet of pulpwood and 10.22 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 22.33 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 8). This optimal management regime will generate the maximum SEV of $455.16 (Table 16), with a NPW of $430.79 per acre (Table 12). This financially optimal rotation could produce an estimated 2,347.65 cubic feet of pulpwood and 13.88 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 22.48 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 8). This optimal management regime will generate the maximum SEV of $137.89 (Table 16), with a NPW of $136.09 per acre (Table 12). This financially optimal rotation could produce an estimated 2,347.65 cubic feet of pulpwood and 13.88 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 22.48 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 8). This optimal management regime will generate the maximum SEV of -$36.49 (Table 16), with a NPW of -$36.37 per acre (Table 12). This financially optimal rotation could produce an estimated 2,347.65 cubic feet of pulpwood and 13.88 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 22.48 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$145.38 (Table 16), with a NPW of -$145.27 per acre (Table 12). This financially optimal rotation could produce an estimated 2,350.79 cubic feet of pulpwood and 14.00 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 22.53 tons of carbon per acre during the rotation (Table 4).

Quaking aspen, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$218.19 (Table 16), with a NPW of -$218.15 per acre (Table 12). This financially optimal rotation could produce an estimated 2,350.79 cubic feet of pulpwood and 14.00 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 22.53 tons of carbon per acre during the rotation (Table 4).

Red Alder (*Alnus rubra*)

Biological Information

Red alder is the most common hardwood in the Pacific Northwest. The native range extends from southeastern Alaska to southern California, generally within 125 miles of the ocean (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/alnus/rubra.htm. June 23, 2006) (Fig. 1).

Fig. 1. The native range of red alder (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/alnus/rubra.htm. June 23, 2006)

Red alder has rapid juvenile growth, and is second only to black cottonwood during the juvenile phase. The maximum attainable age is approximately 100 years. At maturity red alder reaches heights of 100 to 130 feet and diameters of 22 to 30 inches. Site indexes range from 33 to 82 feet on a base age 20 curve. Red alder is classified as intolerant of shade, and self prunes extremely well (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/alnus/rubra.htm. June 23, 2006).

Red alder is used for a variety of special products including furniture, cabinets, case goods, pallets, and novelties. Other products include plywood, flakeboard, tissues, and writing paper. Alder is also a common fuelwood for both domestic and industrial use (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/alnus/rubra.htm. June 23, 2006).

Economic Background

Haight (1993) investigated the effects of market risk on the economics of reforestation practices for Douglas-fir and red alder stands. The decision analysis was to provide estimates of the expected present value of the regeneration options. Published projections of red alder stumpage prices were unavailable, and uncertainty in future prices was high. Regeneration costs were $427 for the HITEC option, and $177 for the CHEAP option. The cost of precommercial removal was $1/tree, and conversion of a 15-year-old stand to a Douglas-fir plantation was $100/acre. The initial red alder stumpage price was set at $0.10 or $0.40/cubic foot. A real discount rate of 4% was used. The data indicate that the economic performance of the low-cost option is superior on land with lower site indices, assuming Douglas-fir dominates the stand and precommercial thinning of red alder is an option.

Atkinson et al. (1979) examined the feasibility of crop rotation of Douglas-fir and red alder. Red alder rotation lengths from 8 to 32 years followed by Douglas-fir rotations of 45 years were considered. Alternate cropping rotations were compared to two pure Douglas-fir scenarios, fertilized and unfertilized. Future costs and returns were discounted at a 7% real rate. Stumpage prices increased at a real rate of 3% per year. The results indicated that all options would earn the required 7% on the investment, and the continuous Douglas-fir cropping produced the greatest returns. Of the mixed cropping stands the 32-year red alder rotations followed by 45-year Douglas-fir rotations generated the greatest returns.

Yoho et al. (1969) examined the economics of converting red alder stands to Douglas-fir. The only cost of red alder management considered was a constant annual cost of $1 or $0.50 per acre. Stumpage prices used for Douglas-fir were approximately twice those used for red alder. As such it was found that in most cases to maximize returns red alder stands should be converted to Douglas-fir, most immediately. More profitable red alder management generally occurred on poorer sites under high conversion costs and low stumpage values. Red alder management is favored more often at high discount rates. It was assumed in this study that as time passed Douglas-fir stumpage would increase at a greater rate than red alder, therefore Douglas-fir stumpage would remain substantially higher than alder. This assumption however does not hold true with current price trends of the two species.

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Species _Red alder_ Region Pacific Northwest Coast

Site indices 60, 70 and 80 (base age 20), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 4.5-in. inside bark top diameter for trees with a minimum of 7 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 9-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 15 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183281412 and 0.519210800, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Helgerson et al. (1988) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Y = 5.13118 + 2.15406 \ln X$$

where:

Y = total dry-weight (g)

X = diameter at breast height (cm)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.6% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $370/mbf (Scribner) (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices) and pulpwood price was assumed to be $0/cord (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of red alder plantations on the Pacific Northwest Coast.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$80.28	Only once	Year 0	
Seedlings[b] (436 seedlings/ac)	$143.88	Only Once	Year 0	
Burning[a]	$21.24	Every 5 years	Year 10	Final Harvest
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al (2005).

[b]The seedling cost was estimated based on the seedling prices from D.L. Philip Nursery Seedling Price List 2005/2006 harvest season (http://www.wrd.state.or.us/ODF/FIELD/Nursery/docs/Availability.pdf. February 12, 2006).

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Table 1. Total tons of carbon sequestered per acre for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	10.01	10.01	10.01	10.01	10.01	10.01
70	10.28	10.28	10.28	10.28	10.28	10.28
80	14.46	10.35	10.35	10.35	10.35	10.35

[1]Base age 20.

Table 2. Total tons of carbon sequestered per acre for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	10.01	10.01	10.01	10.01	10.01	10.01
70	10.28	10.28	10.28	10.28	10.28	10.28
80	14.46	10.35	10.35	10.35	10.35	10.35

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	10.01	10.01	10.01	10.01	10.01	10.01
70	10.28	10.28	10.28	10.28	10.28	10.28
80	14.46	10.35	10.35	10.35	10.35	10.35

[1]Base age 20.

Table 4. Total tons of carbon sequestered per acre for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	10.01	10.01	10.01	10.01	10.01	10.01
70	10.28	10.28	10.28	10.28	10.28	10.28
80	14.46	10.35	10.35	10.35	10.35	10.35

[1]Base age 20.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	**19**[2]	**19**	**19**	**19**	**19**	**19**
70	**18**	**18**	**18**	**18**	**18**	**18**
80	17-**22** (25%)[3]	**17**	**17**	**17**	**17**	**17**

[1]Base age 20.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	**19**[2]	**19**	**19**	**19**	**19**	**19**
70	**18**	**18**	**18**	**18**	**18**	**18**
80	17-**22** (25%)[3]	**17**	**17**	**17**	**17**	**17**

[1]Base age 20.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	**19**[2]	**19**	**19**	**19**	**19**	**19**
70	**18**	**18**	**18**	**18**	**18**	**18**
80	17-**22** (25%)[3]	**17**	**17**	**17**	**17**	**17**

[1]Base age 20.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	**19**[2]	**19**	**19**	**19**	**19**	**19**
70	**18**	**18**	**18**	**18**	**18**	**18**
80	17-**22** (25%)[3]	**17**	**17**	**17**	**17**	**17**

[1]Base age 20.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$4,619.34	$2,779.05	$1,636.79	$919.90	$465.22	$173.91
70	$5,079.10	$3,154.37	$1,930.82	$1,144.78	$634.71	$300.54
80	$6,457.74	$3,336.80	$2,108.40	$1,300.62	$764.36	$405.10

[1]Base age 20.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$4,713.28	$2,864.15	$1,712.61	$986.98	$524.47	$226.38
70	$5,178.02	$3,246.16	$2,014.42	$1,220.29	$702.72	$361.85
80	$6,599.05	$3,433.53	$2,198.33	$1,383.40	$840.24	$474.61

[1]Base age 20.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$4,966.91	$3,093.93	$1,917.31	$1,168.07	$684.47	$368.03
70	$5,445.12	$3,493.96	$2,240.15	$1,424.16	$886.36	$527.36
80	$6,980.58	$3,694.72	$2,441.15	$1,609.90	$1,045.11	$662.28

[1]Base age 20.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$5,089.02	$3,204.56	$2,015.87	$1,255.27	$761.51	$436.23
70	$5,573.73	$3,613.28	$2,348.83	$1,522.33	$974.78	$607.06
80	$7,164.28	$3,820.47	$2,558.06	$1,714.51	$1,143.75	$752.64

[1]Base age 20.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$11,852.71	$4,459.97	$2,140.75	$1,080.51	$513.95	$185.23
70	$13,563.34	$5,220.17	$2,585.00	$1,368.54	$710.51	$323.26
80	$14,903.53	$5,709.01	$2,896.35	$1,585.85	$868.61	$440.71

[1]Base age 20.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$12,093.73	$4,596.54	$2,239.91	$1,159.30	$579.42	$241.11
70	$13,827.51	$5,372.06	$2,696.93	$1,458.81	$786.65	$389.19
80	$15,229.65	$5,874.52	$3,019.89	$1,686.78	$954.84	$516.33

[1]Base age 20.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$12,744.51	$4,965.30	$2,507.64	$1,372.02	$756.18	$391.98
70	$14,540.79	$5,782.16	$2,999.14	$1,702.54	$992.21	$567.22
80	$16,110.17	$6,321.38	$3,353.45	$1,959.30	$1,187.65	$720.50

[1]Base age 20.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for red alder plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$13,057.85	$5,142.85	$2,636.55	$1,474.44	$841.29	$464.62
70	$14,884.22	$5,979.62	$3,144.65	$1,819.89	$1,091.19	$652.94
80	$16,534.13	$6,536.54	$3,514.05	$2,090.51	$1,299.75	$818.80

[1]Base age 20.

Table 17. Volume removed from the financially optimal schedules for red alder plantations by soil productivity and real alternative rates of return in the Pacific Northwest region). (carbon value = $0/ton)

			1st thinning	2nd thinning	Final Harvest	Total Volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
60	2.50%	**19**[3]	-	-	23.18	23.18
	5.00%	**19**	-	-	23.18	23.18
	7.50%	**19**	-	-	23.18	23.18
	10.00%	**19**	-	-	23.18	23.18
	12.50%	**19**	-	-	23.18	23.18
	15.00%	**19**	-	-	23.18	23.18
70	2.50%	**18**	-	-	24.72	24.72
	5.00%	**18**	-	-	24.72	24.72
	7.50%	**18**	-	-	24.72	24.72
	10.00%	**18**	-	-	24.72	24.72
	12.50%	**18**	-	-	24.72	24.72
	15.00%	**18**	-	-	24.72	24.72
80	2.50%	17-**22** (25%)[5]	6.67	-	26.46	33.13
	5.00%	**17**	-	-	24.82	24.82
	7.50%	**17**	-	-	24.82	24.82
	10.00%	**17**	-	-	24.82	24.82
	12.50%	**17**	-	-	24.82	24.82
	15.00%	**17**	-	-	24.82	24.82

[1]Base age 20.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Indicates no operation conducted.
[5]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 18. Volume removed from the financially optimal schedules for red alder plantations by soil productivity and real alternative rates of return in the Pacific Northwest region. (carbon value = $10/ton)

			1st thinning	2nd thinning	Final Harvest	Total Volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
60	2.50%	**19**[3]	-	-	23.18	23.18
	5.00%	**19**	-	-	23.18	23.18
	7.50%	**19**	-	-	23.18	23.18
	10.00%	**19**	-	-	23.18	23.18
	12.50%	**19**	-	-	23.18	23.18
	15.00%	**19**	-	-	23.18	23.18
70	2.50%	**18**	-	-	24.73	24.73
	5.00%	**18**	-	-	24.73	24.73
	7.50%	**18**	-	-	24.73	24.73
	10.00%	**18**	-	-	24.73	24.73
	12.50%	**18**	-	-	24.73	24.73
	15.00%	**18**	-	-	24.73	24.73
80	2.50%	17-**22** (25%)[5]	6.67	-	26.46	33.13
	5.00%	**17**	-	-	24.82	24.82
	7.50%	**17**	-	-	24.82	24.82
	10.00%	**17**	-	-	24.82	24.82
	12.50%	**17**	-	-	24.82	24.82
	15.00%	**17**	-	-	24.82	24.82

[1]Base age 20.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Indicates no operation conducted.
[5]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 19. Volume removed from the financially optimal schedules for red alder plantations by soil productivity and real alternative rates of return in the Pacific Northwest region. (carbon value = $37/ton)

			1st thinning	2nd thinning	Final Harvest	Total Volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
60	2.50%	**19**[3]	-	-	23.18	23.18
	5.00%	**19**	-	-	23.18	23.18
	7.50%	**19**	-	-	23.18	23.18
	10.00%	**19**	-	-	23.18	23.18
	12.50%	**19**	-	-	23.18	23.18
	15.00%	**19**	-	-	23.18	23.18
70	2.50%	**18**	-	-	24.73	24.73
	5.00%	**18**	-	-	24.73	24.73
	7.50%	**18**	-	-	24.73	24.73
	10.00%	**18**	-	-	24.73	24.73
	12.50%	**18**	-	-	24.73	24.73
	15.00%	**18**	-	-	24.73	24.73
80	2.50%	17-**22** (25%)[5]	6.67	-	26.46	33.13
	5.00%	**17**	-	-	24.82	24.82
	7.50%	**17**	-	-	24.82	24.82
	10.00%	**17**	-	-	24.82	24.82
	12.50%	**17**	-	-	24.82	24.82
	15.00%	**17**	-	-	24.82	24.82

[1]Base age 20.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Indicates no operation conducted.
[5]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 20. Volume removed from the financially optimal schedules for red alder plantations by soil productivity and real alternative rates of return in the Pacific Northwest region. (carbon value = $50/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final Harvest MBF	Total Volume MBF
60	2.50%	**19**[3]	-	-	23.18	23.18
	5.00%	**19**	-	-	23.18	23.18
	7.50%	**19**	-	-	23.18	23.18
	10.00%	**19**	-	-	23.18	23.18
	12.50%	**19**	-	-	23.18	23.18
	15.00%	**19**	-	-	23.18	23.18
70	2.50%	**18**	-	-	24.73	24.73
	5.00%	**18**	-	-	24.73	24.73
	7.50%	**18**	-	-	24.73	24.73
	10.00%	**18**	-	-	24.73	24.73
	12.50%	**18**	-	-	24.73	24.73
	15.00%	**18**	-	-	24.73	24.73
80	2.50%	17-**22** (25%)[5]	6.67	-	26.46	33.13
	5.00%	**17**	-	-	24.82	24.82
	7.50%	**17**	-	-	24.82	24.82
	10.00%	**17**	-	-	24.82	24.82
	12.50%	**17**	-	-	24.82	24.82
	15.00%	**17**	-	-	24.82	24.82

[1]Base age 20.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Indicates no operation conducted.
[5]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 21. Financially optimal thinning and final harvest schedules for red alder plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	60	**19**[2]	**19**	0%	**19**	0%	**19**	0%
	70	**18**	**18**	0%	**18**	0%	**18**	0%
	80	17-**22** (25%)[3]	17-**22** (25%)	0%	17-**22** (25%)	0%	17-**22** (25%)	0%
5.00%	60	**19**	**19**	0%	**19**	0%	**19**	0%
	70	**18**	**18**	0%	**18**	0%	**18**	0%
	80	**17**	**17**	0%	**17**	0%	**17**	0%
7.50%	60	**19**	**19**	0%	**19**	0%	**19**	0%
	70	**18**	**18**	0%	**18**	0%	**18**	0%
	80	**17**	**17**	0%	**17**	0%	**17**	0%
10.00%	60	**19**	**19**	0%	**19**	0%	**19**	0%
	70	**18**	**18**	0%	**18**	0%	**18**	0%
	80	**17**	**17**	0%	**17**	0%	**17**	0%
12.50%	60	**19**	**19**	0%	**19**	0%	**19**	0%
	70	**18**	**18**	0%	**18**	0%	**18**	0%
	80	**17**	**17**	0%	**17**	0%	**17**	0%
15.00%	60	**19**	**19**	0%	**19**	0%	**19**	0%
	70	**18**	**18**	0%	**18**	0%	**18**	0%
	80	**17**	**17**	0%	**17**	0%	**17**	0%

[1]Base age 20.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for red alder plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	60	11,852.71	12,093.73	2%	12,744.51	8%	13,057.85	10%
	70	13,563.34	13,827.51	2%	14,540.79	7%	14,884.22	10%
	80	14,903.53	15,229.65	2%	16,110.17	8%	16,534.13	11%
5.00%	60	4,459.97	4,596.54	3%	4,965.30	11%	5,142.85	15%
	70	5,220.17	5,372.06	3%	5,782.16	11%	5,979.62	15%
	80	5,709.01	5,874.52	3%	6,321.38	11%	6,536.54	14%
7.50%	60	2,140.75	2,239.91	5%	2,507.64	17%	2,636.55	23%
	70	2,585.00	2,696.93	4%	2,999.14	16%	3,144.65	22%
	80	2,896.35	3,019.89	4%	3,353.45	16%	3,514.05	21%
10.00%	60	1,080.51	1,159.30	7%	1,372.02	27%	1,474.44	36%
	70	1,368.54	1,458.81	7%	1,702.54	24%	1,819.89	33%
	80	1,585.85	1,686.78	6%	1,959.30	24%	2,090.51	32%
12.50%	60	513.95	579.42	13%	756.18	47%	841.29	64%
	70	710.51	786.65	11%	992.21	40%	1,091.19	54%
	80	868.61	954.84	10%	1,187.65	37%	1,299.75	50%
15.00%	60	185.23	241.11	30%	391.98	112%	464.62	151%
	70	323.26	389.19	20%	567.22	75%	652.94	102%
	80	440.71	516.33	17%	720.50	63%	818.80	86%

[1]Base age 20.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

Pacific Northwest- Red alder - Timber Only Rotations (C = $0/ton)

Red alder, Site Index 60 (base age 20), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 5). This optimal management regime will generate the maximum SEV of $11,852.71 (Table 13), with a NPW of $4,619.34 per acre (Table 9). This means that $11,852.71 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 90 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $4,619.34 per acre for managing one rotation, or $11,852.71 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.01 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red alder, Site Index 60 (base age 20), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 5). This optimal management regime will generate the maximum SEV of $4,459.97 (Table 13), with a NPW of $2,779.05 per acre (Table 9). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.01 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 60 (base age 20), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 5). This optimal management regime will generate the maximum SEV of $2,140.75 (Table 13), with a NPW of $1,636.79 per acre (Table 9). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.01 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 60 (base age 20), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 5). This optimal management regime will generate the maximum SEV of $1,080.51 (Table 13), with a NPW of $919.90 per acre (Table 9). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.01 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 60 (base age 20), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 5). This optimal management regime will generate the maximum SEV of $513.95 (Table 13), with a NPW of $465.22 per acre (Table 9). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.01 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 60 (base age 20), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 5). This optimal management regime will generate the maximum SEV of $185.23 (Table 13), with a NPW of $173.91 per acre (Table 9). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.01 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 70 (base age 20), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 5). This optimal management regime will generate the maximum SEV of $13,563.34 (Table 13), with a NPW of $5,079.10 per acre (Table 9). This financially optimal rotation would produce an estimated 24.72 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.28 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 70 (base age 20), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 5). This optimal management regime will generate the maximum SEV of $5,220.17 (Table 13), with a NPW of $3,154.37 per acre (Table 9). This financially optimal rotation would produce an estimated 24.72 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.28 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 70 (base age 20), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 5). This

optimal management regime will generate the maximum SEV of $2,585.00 (Table 13), with a NPW of $1,930.82 per acre (Table 9). This financially optimal rotation would produce an estimated 24.72 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.28 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 70 (base age 20), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 5). This optimal management regime will generate the maximum SEV of $1,368.54 (Table 13), with a NPW of $1,144.78 per acre (Table 9). This financially optimal rotation would produce an estimated 24.72 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.28 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 70 (base age 20), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 5). This optimal management regime will generate the maximum SEV of $710.51 (Table 13), with a NPW of $634.71 per acre (Table 9). This financially optimal rotation would produce an estimated 24.72 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.28 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 70 (base age 20), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 5). This optimal management regime will generate the maximum SEV of $323.26 (Table 13), with a NPW of $300.54 per acre (Table 9). This financially optimal rotation would

produce an estimated 24.72 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.28 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 80 (base age 20), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 5). This optimal management regime will generate the maximum SEV of $14,903.53 (Table 13), with a NPW of $6,457.74 per acre (Table 9). This financially optimal rotation would produce an estimated 33.13 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 14.46 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 80 (base age 20), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 5). This optimal management regime will generate the maximum SEV of $5,709.01 (Table 13), with a NPW of $3,336.80 per acre (Table 9). This financially optimal rotation would produce an estimated 24.82 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.35 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 80 (base age 20), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 5). This optimal management regime will generate the maximum SEV of $2,896.35 (Table 13), with a NPW of $2,108.40 per acre (Table 9). This financially optimal rotation would

produce an estimated 24.82 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.35 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 80 (base age 20), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 5). This optimal management regime will generate the maximum SEV of $1,585.85 (Table 13), with a NPW of $1,300.62 per acre (Table 9). This financially optimal rotation would produce an estimated 24.82 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.35 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 80 (base age 20), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 5). This optimal management regime will generate the maximum SEV of $868.61 (Table 13), with a NPW of $764.36 per acre (Table 9). This financially optimal rotation would produce an estimated 24.82 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.35 net tons of carbon per acre during one rotation (Table 1).

Red alder, Site Index 80 (base age 20), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 5). This optimal management regime will generate the maximum SEV of $440.71 (Table 13), with a NPW of $405.10 per acre (Table 9). This financially optimal rotation would produce an estimated 24.82 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 10.35 net tons of carbon per acre during one rotation (Table 1).

<u>Pacific Northwest- Red alder - Timber + Carbon Rotations (C = $10/ton)</u>

Red alder, Site Index 60 (base age 20), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 6). This optimal management regime will generate the maximum SEV of $12,093.73 (Table 14), with a NPW of $4,713.28 per acre (Table 10). This means that $12,093.73 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 90 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $4,713.28 per acre for managing one rotation, or $12,093.73 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.01 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red alder, Site Index 60 (base age 20), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 6). This optimal management regime will generate the maximum SEV of $4,596.54 (Table 14), with a NPW of $2,864.15 per acre (Table 10). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.01 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 60 (base age 20), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 6). This optimal management regime will generate the maximum SEV of $2,239.91 (Table 14), with a NPW of $1,712.61 per acre (Table 10). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.01 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 60 (base age 20), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 6). This optimal management regime will generate the maximum SEV of $1,159.30 (Table 14), with a NPW of $986.98 per acre (Table 10). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 10.01 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 60 (base age 20), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 6). This optimal management regime will generate the maximum SEV of $579.42 (Table 14), with a NPW of $524.47 per acre (Table 10). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.01 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 60 (base age 20), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 6). This optimal management regime will generate the maximum SEV of $241.11 (Table 14), with a NPW of $226.38 per acre (Table 10). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.01 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 70 (base age 20), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 6). This optimal management regime will generate the maximum SEV of $13,827.51 (Table 14), with a NPW of $5,178.02 per acre (Table 10). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 10.28 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 70 (base age 20), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 6). This optimal management regime will generate the maximum SEV of $5,372.06 (Table 14), with a NPW of $3,246.16 per acre (Table 10). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.28 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 70 (base age 20), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 6). This

optimal management regime will generate the maximum SEV of $2,696.93 (Table 14), with a NPW of $2,014.42 per acre (Table 10). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.28 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 70 (base age 20), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 6). This optimal management regime will generate the maximum SEV of $1,458.81 (Table 14), with a NPW of $1,220.29 per acre (Table 10). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.28 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 70 (base age 20), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 6). This optimal management regime will generate the maximum SEV of $786.65 (Table 14), with a NPW of $702.72 per acre (Table 10). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.28 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 70 (base age 20), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 6). This optimal management regime will generate the maximum SEV of $389.19 (Table 14), with a NPW of $361.85 per acre (Table 10). This financially optimal rotation would

produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.28 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 80 (base age 20), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 6). This optimal management regime will generate the maximum SEV of $15,229.65 (Table 14), with a NPW of $6,599.05 per acre (Table 10). This financially optimal rotation would produce an estimated 33.13 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 14.46 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 80 (base age 20), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 6). This optimal management regime will generate the maximum SEV of $5,874.52 (Table 14), with a NPW of $3,433.53 per acre (Table 10). This financially optimal rotation could produce an estimated 24.82 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.35 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 80 (base age 20), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest in conducted at stand age 17 (Table 6). This optimal management regime will generate the maximum SEV of $3,019.89 (Table 14), with a NPW of $2,198.33 per acre (Table 10). This financially optimal rotation would

produce an estimated 24.82 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.35 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 80 (base age 20), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 6). This optimal management regime will generate the maximum SEV of $1,686.78 (Table 14), with a NPW of $1,383.40 per acre (Table 10). This financially optimal rotation would produce an estimated 24.82 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.35 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 80 (base age 20), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 6). This optimal management regime will generate the maximum SEV of $954.84 (Table 14), with a NPW of $840.24 per acre (Table 10). This financially optimal rotation would produce an estimated 24.82 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.35 net tons of carbon per acre during one rotation (Table 2).

Red alder, Site Index 80 (base age 20), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 6). This optimal management regime will generate the maximum SEV of $516.33 (Table 14), with a NPW of $474.61 per acre (Table 10). This financially optimal rotation would produce an estimated 24.82 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 10.35 net tons of carbon per acre during one rotation (Table 2).

Pacific Northwest- Red alder - Timber + Carbon Rotations (C = $37/ton)

Red alder, Site Index 60 (base age 20), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 7). This optimal management regime will generate the maximum SEV of $12,744.51 (Table 15), with a NPW of $4,966.91 per acre (Table 11). This means that $12,744.51 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 90 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $4,966.91 per acre for managing one rotation, or $12,744.51 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 10.01 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red alder, Site Index 60 (base age 20), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 7). This optimal management regime will generate the maximum SEV of $4,965.30 (Table 15), with a NPW of $3,093.93 per acre (Table 11). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 10.01 net tons of carbon per acre during one rotation (Table 3).

Red alder, Site Index 60 (base age 20), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 7). This optimal management regime will generate the maximum SEV of $2,507.64 (Table 15), with a NPW of $1,917.31 per acre (Table 11). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 10.01 net tons of carbon per acre during one rotation (Table 3).

Red alder, Site Index 60 (base age 20), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 7). This optimal management regime will generate the maximum SEV of $1,372.02 (Table 15), with a NPW of $1,168.07 per acre (Table 11). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 10.01 net tons of carbon per acre during one rotation (Table 3).

Red alder, Site Index 60 (base age 20), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 7). This optimal management regime will generate the maximum SEV of $756.18 (Table 15), with a NPW of $684.47 per acre (Table 11). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 10.01 tons of carbon per acre during the rotation (Table 3).

Red alder, Site Index 60 (base age 20), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 7). This optimal management regime will generate the maximum SEV of $391.98 (Table 15), with a NPW of $368.03 per acre (Table 11). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 10.01 tons of carbon per acre during the rotation (Table 3).

Red alder, Site Index 70 (base age 20), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 7). This optimal management regime will generate the maximum SEV of $14,540.79 (Table 15), with a NPW of $5,445.12 per acre (Table 11). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 10.28 net tons of carbon per acre during one rotation (Table 3).

Red alder, Site Index 70 (base age 20), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 7). This optimal management regime will generate the maximum SEV of $5,782.16 (Table 15), with a NPW of $3,493.96 per acre (Table 11). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 10.28 net tons of carbon per acre during one rotation (Table 3).

Red alder, Site Index 70 (base age 20), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 7). This

optimal management regime will generate the maximum SEV of $2,999.14 (Table 15), with a NPW of $2,240.15 per acre (Table 11). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 10.28 net tons of carbon per acre during one rotation (Table 3).

Red alder, Site Index 70 (base age 20), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 7). This optimal management regime will generate the maximum SEV of $1,702.54 (Table 15), with a NPW of $1,424.16 per acre (Table 11). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 10.28 net tons of carbon per acre during one rotation (Table 3).

Red alder, Site Index 70 (base age 20), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 7). This optimal management regime will generate the maximum SEV of $992.21 (Table 15), with a NPW of $886.36 per acre (Table 11). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 10.28 net tons of carbon per acre during one rotation (Table 3).

Red alder, Site Index 70 (base age 20), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 7). This optimal management regime will generate the maximum SEV of $567.22 (Table 15), with a NPW of $527.36 per acre (Table 11). This financially optimal rotation would

produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 10.28 net tons of carbon per acre during one rotation (Table 3).

Red alder, Site Index 80 (base age 20), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 7). This optimal management regime will generate the maximum SEV of $16,110.17 (Table 15), with a NPW of $6,980.58 per acre (Table 11). This financially optimal rotation would produce an estimated 33.13 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 14.46 net tons of carbon per acre during one rotation (Table 3).

Red alder, Site Index 80 (base age 20), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 7). This optimal management regime will generate the maximum SEV of $6,321.38 (Table 15), with a NPW of $3,694.72 per acre (Table 11). This financially optimal rotation would produce an estimated 24.82 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 10.35 net tons of carbon per acre during one rotation (Table 3).

Red alder, Site Index 80 (base age 20), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 7). This optimal management regime will generate the maximum SEV of $3,353.45 (Table 15), with a NPW of $2,441.15 per acre (Table 11). This financially optimal rotation would

produce an estimated 24.82 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 10.35 net tons of carbon per acre during one rotation (Table 3).

Red alder, Site Index 80 (base age 20), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 7). This optimal management regime will generate the maximum SEV of $1,959.30 (Table 15), with a NPW of $1,609.90 per acre (Table 11). This financially optimal rotation would produce an estimated 24.82 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 10.35 net tons of carbon per acre during one rotation (Table 3).

Red alder, Site Index 80 (base age 20), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 7). This optimal management regime will generate the maximum SEV of $1,187.65 (Table 15), with a NPW of $1,045.11 per acre (Table 11). This financially optimal rotation would produce an estimated 24.82 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 10.35 tons of carbon per acre during one rotation (Table 3).

Red alder, Site Index 80 (base age 20), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 7). This optimal management regime will generate the maximum SEV of $720.50 (Table 15), with a NPW of $662.28 per acre (Table 11). This financially optimal rotation would produce an estimated 24.82 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 10.35 net tons of carbon per acre during one rotation (Table 3).

Pacific Northwest- Red alder - Timber + Carbon Rotations (C = $50/ton)

Red alder, Site Index 60 (base age 20), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 8). This optimal management regime will generate the maximum SEV of $13,057.85 (Table 16), with a NPW of $5,089.02 per acre (Table 12). This means that $13,057.85 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 90 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $5,089.02 per acre for managing one rotation, or $13,057.85 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 10.01 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red alder, Site Index 60 (base age 20), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 8). This optimal management regime will generate the maximum SEV of $5,142.85 (Table 16), with a NPW of $3,204.56 per acre (Table 12). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 10.01 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 60 (base age 20), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 8). This optimal management regime will generate the maximum SEV of $2,636.55 (Table 16), with a NPW of $2,015.87 per acre (Table 12). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 10.01 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 60 (base age 20), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 8). This optimal management regime will generate the maximum SEV of $1,474.44 (Table 16), with a NPW of $1,255.27 per acre (Table 12). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 10.01 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 60 (base age 20), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 8). This optimal management regime will generate the maximum SEV of $841.29 (Table 16), with a NPW of $761.51 per acre (Table 12). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 10.01 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 60 (base age 20), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 8). This optimal management regime will generate the maximum SEV of $464.62 (Table 16), with a NPW of $436.23 per acre (Table 12). This financially optimal rotation would produce an estimated 23.18 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 10.01 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 70 (base age 20), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 8). This optimal management regime will generate the maximum SEV of $14,884.22 (Table 16), with a NPW of $5,573.73 per acre (Table 12). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 10.28 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 70 (base age 20), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 8). This optimal management regime will generate the maximum SEV of $5,979.62 (Table 16), with a NPW of $3,613.28 per acre (Table 12). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 10.28 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 70 (base age 20), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 8). This

optimal management regime will generate the maximum SEV of $3,144.65 (Table 16), with a NPW of $2,348.83 per acre (Table 12). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 10.28 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 70 (base age 20), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 8). This optimal management regime will generate the maximum SEV of $1,819.89 (Table 16), with a NPW of $1,522.33 per acre (Table 12). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 10.28 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 70 (base age 20), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 8). This optimal management regime will generate the maximum SEV of $1,091.19 (Table 16), with a NPW of $974.78 per acre (Table 12). This financially optimal rotation would produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 10.28 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 70 (base age 20), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 18 (Table 8). This optimal management regime will generate the maximum SEV of $652.94 (Table 16), with a NPW of $607.06 per acre (Table 12). This financially optimal rotation would

produce an estimated 24.73 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 10.28 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 80 (base age 20), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 8). This optimal management regime will generate the maximum SEV of $16,534.13 (Table 16), with a NPW of $7,164.28 per acre (Table 12). This financially optimal rotation would produce an estimated 33.13 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 14.46 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 80 (base age 20), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 8). This optimal management regime will generate the maximum SEV of $6,536.54 (Table 16), with a NPW of $3,820.47 per acre (Table 12). This financially optimal rotation would produce an estimated 24.82 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 10.35 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 80 (base age 20), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 8). This optimal management regime will generate the maximum SEV of $3,514.05 (Table 16), with a NPW of $2,558.06 per acre (Table 12). This financially optimal rotation would

produce an estimated 24.82 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 10.35 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 80 (base age 20), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 8). This optimal management regime will generate the maximum SEV of $2,090.51 (Table 16), with a NPW of $1,714.51 per acre (Table 12). This financially optimal rotation would produce an estimated 24.82 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 10.35 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 80 (base age 20), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 8). This optimal management regime will generate the maximum SEV of $1,299.75 (Table 16), with a NPW of $1,143.75 per acre (Table 12). This financially optimal rotation would produce an estimated 24.82 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 10.35 net tons of carbon per acre during one rotation (Table 4).

Red alder, Site Index 80 (base age 20), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 8). This optimal management regime will generate the maximum SEV of $818.80 (Table 16), with a NPW of $752.64 per acre (Table 12). This financially optimal rotation would produce an estimated 38.84 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 30.58 net tons of carbon per acre during one rotation (Table 4).

Red maple – Acer rubrum

Biological information

Red maple is also referred as scarlet maple, swamp maple, soft maple, Carolina red maple, Drummond red maple, and water maple. On good sites, it may grow very well as sawlogs, while it may be defective and considered to be undesirable if it grows on poor sites. It is shade tolerant and ranks high as a shade tree for landscapes (Silvics Manual. USDA Forest Services. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/acer/rubrum.htm. May 7, 2006).

Red maple grows throughout most of eastern North America. It ranges from southern Newfoundland, Nova Scotia, and southern Quebec to southern and southwestern Ontario, extreme southeastern Manitoba, and northern Minnesota; south to Wisconsin, Illinois, Missouri, eastern Oklahoma, and eastern Texas; and east to Florida (Silvics Manual. USDA Forest Services. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/acer/rubrum.htm. May 7, 2006) (Fig. 1).

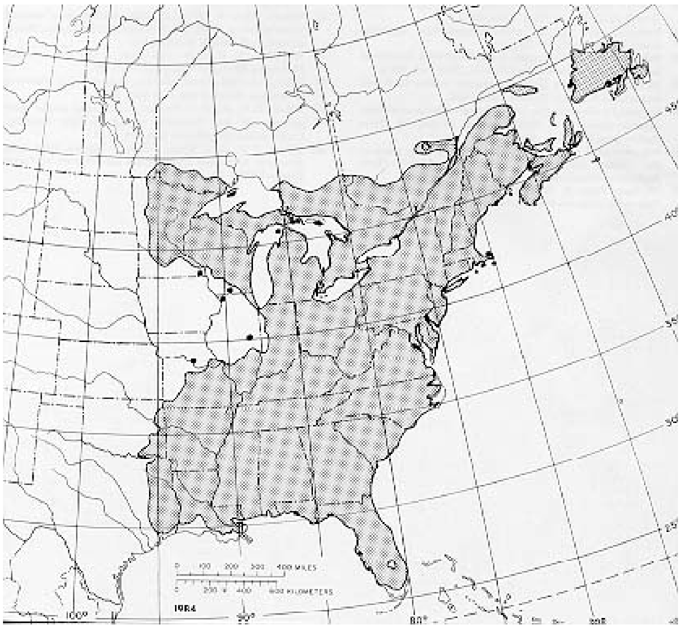

Fig. 1 The native range of red maple (Silvics Manual. USDA Forest Services. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/acer/rubrum.htm. May 7, 2006).

Red maple is a short-to medium-lived tree, which reaches its maturity at 70-80 years and seldom lives longer than 150 years. It reaches a growth of 60-90 ft. in height and 18 to 30 in. in diameter at maturity. It grows fast during early life but slows down after passing the pole class(Silvics Manual. USDA Forest Services. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/acer/rubrum.htm. May 7, 2006).

According to records in Michigan and the Canadian Maritimes, red maple responds very well to thinning. In the north, red maple has a better growth rate than sugar maple, beech and yellow birch, but grows slower than aspen, paper birch, or white ash (Silvics Manual. USDA Forest Services.

http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/acer/rubrum.htm. May 7, 2006).

Red maple is merchandized as soft maple. The wood is soft, light in weight, and not very strong. It is also makes an excellent ornamental tree because of its brilliant fall foliage. Red maple is sometimes used for syrup and sugar production. The sweetness, flavor, and quality are considered to be equal to those of red and silver maple, boxelder, and Norway maple. Red maple is also a valuable source of wildlife browse. Along with aspen, it is considered an important source of winter food for elk and white-tail deer. Slash residue from timber harvesting can provide a source of browse to help sustain animals in winter (Silvics Manual. USDA Forest Services. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/acer/rubrum.htm. May 7, 2006).

Economic information

Gresez and Mendel (1971) conducted an economic analysis to determine the rate of value increase for black cherry, red maple, and white ash in New York and Pennsylvania. The objective of the study was to use the compound interest rate of return to analyze whether a tree or a stand is financially mature. Rates of value increase were calculated for different d.b.h and vigor classes for these three species in even aged stands. The authors suggest that any stand that would earn less than minimum acceptable rate of return should be clearcut and the money thus obtained should be invested in other trees or stands, or in alternative investments.

Literature cited

Grisez, T.J. and J.J. Mendel. 1971. The rate of value increase for Black cherry, Red maple, and White ash. USDA For. Serv. Res. pap. NE-231. Upper Darby. PA. 26 p.

Species red maple Region Central States

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 5.80, 7.00, and 8.40 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 25 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183482143 and 0.446428571, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Perala and Alban (1994) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$Y = 0.02347D^{1.888}H^{0..9912}*1000$$

where:

Y = component dry-weight (kg.)

D = diameter at breast height (cm.)

H = height (cm.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be \$120/mbf (International 1/4) (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005) and pulpwood price was assumed to be \$17/cord (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005). The price of carbon was assumed to be \$0, \$10, \$37 or \$50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of red maple plantations in the Central States.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$130.8	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]The seedling cost was estimated based on the seedling prices from Minnesota DNR State Forest Nursery (http://www.dnr.state.mn.us/forestry/nurseries/pricelist.html. January 18, 2006) and Lee's Nursery, Inc. (http://www.leenursery.com/Seedling2006Catalog.pdf. January 18, 2006).

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Table 1. Total tons of carbon sequestered per acre for red maple plantations in the central states United States by site index and real alternative rates of return. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	23.15	19.47	19.33	17.29	17.29	17.29
80	25.28	24.59	20.97	20.97	20.97	18.70
90	29.25	26.26	25.49	25.03	20.70	20.70

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for red maple plantations in the central states United States by site index and real alternative rates of return. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	23.15	20.00	19.47	19.47	18.30	18.06
80	25.28	24.59	23.95	22.36	22.36	19.71
90	29.25	26.26	25.91	25.91	25.91	21.80

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for red maple plantations in the central states United States by site index and real alternative rates of return. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	23.25	20.88	20.88	19.47	19.47	19.47
80	25.61	24.94	24.59	23.07	23.07	22.96
90	29.25	29.25	26.26	26.63	26.31	26.31

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for red maple plantations in the central states United States by site index and real alternative rates of return. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	23.25	22.36	20.88	20.88	20.88	20.92
80	25.61	25.28	24.94	24.59	23.07	23.07
90	29.25	29.25	29.17	26.26	26.26	26.26

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red maple plantations by site index and real alternative rates of return in the central states United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	51-56-**76**[2] (30%)[3]	<41-51-**56>**[4] (20%)	<40-51-**56**> (20%)	<34-**50**> (30%)	<34-**50**> (30%)	<34-**50**> (30%)
80	47-52-**67** **(**30%**)**	<47-52-**65**> (30%)	<30-46-**51**> (30%)	<30-46-**51**> (30%)	<30-46-**51**> (30%)	<30-35-**46**> (30%)
90	44-54-**66** (30%)	<43-52-**58**> (30%)	<32-43-**51**> (25%)	<30-43-**51**> (25%)	<30-**43**> (30%)	<30-**43**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red maple plantations by site index and real alternative rates of return in the central states United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	51-56-**76**[2] (30%)[3]	<51-56-**66>**[4] (20%)	<41-51-**56**> (20%)	<41-51-**56**> (20%)	<40-**51**> (25%)	<40-**50**> (30%)
80	47-52-**67** (30%)	<47-52-**65**> (30%)	<37-46-**57**> (30%)	<37-46-**52**> (30%)	<37-46-**52**> (30%)	<36-**46**> (25%)
90	44-54-**66** (30%)	43-52-**58** (30%)	<35-43-**51**> (25%)	<35-43-**51**> (25%)	<35-43-**51**> (25%)	<35-**43**> (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red maple plantations by site index and real alternative rates of return in the central states United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	51-58-**76**[2] (30%)[3]	42-51-**64** (20%)	<42-51-**64**>[4] (20%)	<41-51-**56**> (20%)	<41-51-**56**> (20%)	<41-51-**56**> (20%)
80	47-52-**68** (30%)	47-52-**66** (30%)	<47-52-**65**> (30%)	<40-47-**57**> (20%)	<40-47-**57**> (20%)	<40-46-**57**> (20%)
90	44-54-**66** (30%)	44-54-**66** (30%)	43-52-**58** (30%)	<35-44-**52**> (25%)	<37-43-**52**> (25%)	<37-43-**52**> (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red maple plantations by site index and real alternative rates of return in the central states United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	51-58-**76**[2] (30%)[3]	51-61-**76** (25%)	<42-51-**64>**[4] (20%)	<42-51-**64>** (20%)	<42-51-**64>** (20%)	<42-51-**64>** (20%)
80	47-52-**68** (30%)	47-52-**67** (30%)	47-52-**66** (30%)	<47-52-**65>** (30%)	<40-47-**57>** (20%)	<40-47-**57>** (20%)
90	44-54-**66** (30%)	44-54-**66** (30%)	43-52-**65** (30%)	<43-52-**58>** (30%)	<43-52-**58>** (30%)	<43-52-**58>** (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the central states United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$299.15	-$234.65	-$340.00	-$365.42	-$373.15	-$375.21
80	$450.33	-$187.02	-$319.58	-$358.45	-$370.50	-$373.65
90	$627.71	-$135.12	-$300.43	-$352.01	-$366.76	-$372.30

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the central states United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$474.36	-$139.89	-$278.35	-$327.53	-$347.09	-$356.63
80	$646.86	-$62.86	-$247.86	-$310.11	-$336.78	-$349.43
90	$860.64	$9.68	-$208.82	-$290.00	-$324.89	-$341.40

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the central states United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$948.52	$136.49	-$112.13	-$219.32	-$274.41	-$305.52
80	$1,184.57	$273.81	-$38.85	-$173.37	-$242.61	-$282.33
90	$1,489.54	$416.96	$41.96	-$120.95	-$206.70	-$256.48

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the central states United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,177.30	$277.09	-$29.24	-$167.15	-$239.33	-$280.83
80	$1,442.50	$437.13	$64.08	-$106.51	-$196.64	-$249.58
90	$1,792.34	$614.00	$167.84	-$38.30	-$149.25	-$215.08

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the central states United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$351.68	-$250.16	-$345.61	-$368.27	-$374.07	-$375.52
80	$553.60	-$194.80	-$327.20	-$361.00	-$371.31	-$374.17
90	$776.11	-$143.17	-$307.59	-$354.51	-$368.83	-$373.10

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the central states United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$557.66	-$145.43	-$282.93	-$328.97	-$347.85	-$356.92
80	$795.20	-$65.48	-$251.65	-$312.11	-$337.43	-$349.92
90	$1,064.10	$10.26	-$213.80	-$292.06	-$325.60	-$342.13

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the central states United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,115.08	$142.46	-$113.16	-$220.28	-$274.74	-$305.63
80	$1,448.12	$284.64	-$39.18	-$174.06	-$242.87	-$282.42
90	$1,841.68	$433.45	$42.55	-$121.73	-$207.10	-$256.64

[1]Base age 50.

Table16. Soil expectation value of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the central states United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,384.03	$283.71	-$29.50	-$167.50	-$239.45	-$280.87
80	$1,763.43	$453.57	$64.58	-$106.71	-$196.85	-$249.66
90	$2,216.07	$638.28	$169.27	-$38.44	-$149.39	-$215.14

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for Northern red oak plantations by soil productivity and real alternative rates of return in the central states United States. (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	51-56-**76**[3] (30%)[4]	666.08	3.19	385.95	3.77	854.64	23.70	1906.67	30.66
	5.00%	<41-51-**56**> (20%)	670.79	0	444.20	2.13	1402.03	13.71	2517.02	15.84
	7.50%	<40-51-**56**> (20%)	632.36	0	444.22	2.13	1402.06	13.71	2478.64	15.84
	10.00%	<34-**50**> (30%)	625.20	0	-[5]	-	2024.32	9.80	2649.52	9.80
	12.50%	<34-**50**> (30%)	625.20	0	-	-	2024.32	9.80	2649.52	9.80
	15.00%	<34-**50**> (30%)	625.20	0	-	-	2024.32	9.80	2649.52	9.80
80	2.50%	47-52-**67** (30%)	666.06	3.19	506.73	3.83	1226.42	22.87	2399.21	29.90
	5.00%	<47-52-**65**> (30%)	666.06	3.19	506.73	3.83	887.32	21.63	2060.11	28.65
	7.50%	<30-46-**51**> (30%)	570.93	0	629.62	3.02	1592.12	12.04	2792.67	15.05
	10.00%	<30-46-**51**> (30%)	570.93	0	629.62	3.02	1592.12	12.04	2792.67	15.05
	12.50%	<30-46-**51**> (30%)	570.93	0	629.62	3.02	1592.12	12.04	2792.67	15.05
	15.00%	<30-35-**46**> (30%)	570.93	0	655.67	0	1697.79	8.13	2924.39	8.13
90	2.50%	44-54-**66** (30%)	793.50	3.19	525.72	5.65	1122.68	27.00	2441.90	35.84
	5.00%	<43-52-**58**> (30%)	861.53	2.75	515.14	5.52	1040.07	19.25	2416.74	27.52
	7.50%	<32-43-**51**> (25%)	686.68	0	636.52	2.56	1719.12	17.77	3042.32	20.33
	10.00%	<30-43-**51**> (25%)	610.46	0	631.40	2.54	1712.30	17.70	2954.16	20.24
	12.50%	<30-**43**> (30%)	733.93	0	-	-	2420.99	9.73	3154.92	9.73
	15.00%	<30-**43**> (30%)	733.93	0	-	-	2420.99	9.73	3154.92	9.73

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 18. Volume removed from the financially optimal schedules for red maple plantations by soil productivity and real alternative rates of return in the central states United States. (carbon value = $10/ton)

Site Index[1]	ARR	Schedule	1st thinning		2nd thinning		Final Harvest		Total Volume	
			Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	51-56-**76**[3] (30%)[4]	666.08	3.19	385.95	3.77	854.64	23.70	1906.67	30.66
	5.00%	<51-56-**66**> (20%)	555.03	2.66	327.94	3.20	1096.93	16.97	1979.90	22.84
	7.50%	<41-51-**56**> (20%)	670.79	0	444.20	2.13	1402.03	13.71	2517.02	15.84
	10.00%	<41-51-**56**> (20%)	670.79	0	444.20	2.13	1402.03	13.71	2517.02	15.84
	12.50%	<40-**51**> (25%)	792.51	0	-[5]	-	2219.06	10.66	3011.57	10.66
	15.00%	<40-**50**> (30%)	952.68	0	-	-	1989.80	9.64	2942.48	9.64
80	2.50%	47-52-**67** (30%)	666.06	3.19	506.73	3.83	1226.42	22.87	2399.21	29.89
	5.00%	<47-52-**65**> (30%)	666.06	3.19	506.73	3.83	887.32	21.63	2060.11	28.65
	7.50%	<37-46-**57**> (30%)	957.89	0	608.34	2.91	1254.36	17.36	2820.59	20.27
	10.00%	<37-46-**52**> (30%)	957.89	0	608.34	2.91	1610.81	12.19	3177.04	15.10
	12.50%	<37-46-**52**> (30%)	957.89	0	608.34	2.91	1610.81	12.19	3177.04	15.10
	15.00%	<36-**46**> (25%)	757.83	0	-	-	2187.03	10.48	2944.86	10.48
90	2.50%	44-54-**66** (30%)	793.50	3.19	525.72	5.65	1122.68	27.00	2441.90	35.84
	5.00%	43-52-**58** (30%)	861.53	2.75	515.14	5.52	1040.07	19.25	2416.74	27.52
	7.50%	<35-43-**51**> (25%)	893.28	0	626.33	2.52	1710.29	17.59	3229.90	20.11
	10.00%	<35-43-**51**> (25%)	893.28	0	626.33	2.52	1710.29	17.59	3229.90	20.11
	12.50%	<35-43-**51**> (25%)	893.28	0	626.33	2.52	1710.29	17.59	3229.90	20.11
	15.00%	<35-**43**> (20%)	713.16	0	-	-	2648.86	10.65	3362.02	10.65

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for red maple plantations by soil productivity and real alternative rates of return in the central states United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	51-58-**76**[3] (30%)[4]	666.08	3.19	411.27	4.03	846.87	23.48	1924.22	30.71
	5.00%	42-51-**64** (20%)	682.52	0	444.50	2.13	947.75	19.21	2074.77	21.35
	7.50%	<42-51-**64>** (20%)	682.52	0	444.50	2.13	947.75	19.21	2074.77	21.35
	10.00%	<41-51-**56**> (20%)	670.79	0	444.20	2.13	1402.03	13.71	2517.02	15.84
	12.50%	<41-51-**56**> (20%)	670.79	0	444.20	2.13	1402.03	13.71	2517.02	15.84
	15.00%	<41-51-**56**> (20%)	670.79	0	444.20	2.13	1402.03	13.71	2517.02	15.84
80	2.50%	47-52-**68 (**30%)	666.06	3.19	506.73	3.83	1253.63	23.41	2426.42	30.43
	5.00%	47-52-**66** (30%)	666.06	3.19	506.73	3.83	1080.59	22.33	2253.38	29.35
	7.50%	<47-52-**65>** (30%)	666.06	3.19	506.73	3.83	887.32	21.63	2060.11	28.65
	10.00%	<40-47-**57**> (20%)	690.27	0	444.90	2.13	1383.58	19.15	2518.75	21.28
	12.50%	<40-47-**57**> (20%)	690.27	0	444.90	2.13	1383.58	19.15	2518.75	21.28
	15.00%	<40-46-**57**> (20%)	690.27	0	445.63	2.01	1382.08	19.13	2517.98	21.13
90	2.50%	47-64-**85** (30%)	793.50	3.19	525.72	5.65	1122.68	27.00	2441.90	35.84
	5.00%	47-61-**75** (30%)	793.50	3.19	525.72	5.65	1122.68	27.00	2441.90	35.84
	7.50%	<47-61-**68>** (30%)	861.53	2.75	515.14	5.52	1040.07	19.25	2416.74	27.52
	10.00%	<47-61-**66>** (30%)	893.28	0	654.58	2.63	1719.74	18.43	3267.60	21.06
	12.50%	<49-**61**> (20%)	956.80	0	609.25	2.45	1693.09	18.14	3259.14	20.59
	15.00%	<48-**60**> (20%)	956.80	0	609.25	2.45	1693.09	18.14	3259.14	20.59

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 20. Volume removed from the financially optimal schedules for red maple plantations by soil productivity and real alternative rates of return in the central states United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	51-58-**76**[2] (30%)[3]	666.08	3.19	411.27	4.03	846.87	23.48	1924.22	30.71
	5.00%	51-61-**76** (25%)	555.03	2.66	381.51	3.75	854.23	23.69	1790.77	30.10
	7.50%	<42-51-**64**>**[4]** (20%)	682.52	0	444.50	2.13	947.75	19.21	2074.77	21.35
	10.00%	<42-51-**64**> (20%)	682.52	0	444.50	2.13	947.75	19.21	2074.77	21.35
	12.50%	<42-51-**64**> (20%)	682.52	0	444.50	2.13	947.75	19.21	2074.77	21.35
	15.00%	<42-51-**64**> (20%)	691.08	0	444.93	2.13	946.86	19.23	2082.87	21.36
80	2.50%	47-52-**68 (**30%**)**	666.06	3.19	506.73	3.83	1253.63	23.41	2426.42	30.43
	5.00%	47-52-**67** (30%)	666.06	3.19	506.73	3.83	1226.42	22.87	2399.21	29.90
	7.50%	47-52-**66** (30%)	666.06	3.19	506.73	3.83	1080.59	22.33	2253.38	29.35
	10.00%	<47-52-**65**> (30%)	666.06	3.19	506.73	3.83	887.32	21.63	2060.11	28.65
	12.50%	<40-47-**57**> (20%)	690.27	0.00	444.90	2.13	1383.58	19.15	2518.75	21.28
	15.00%	<40-47-**57**> (20%)	690.27	0.00	444.90	2.13	1383.58	19.15	2518.75	21.28
90	2.50%	44-54-**66** (30%)	793.50	3.19	525.72	5.65	1122.68	27.00	2441.90	35.84
	5.00%	44-54-**66** (30%)	793.50	3.19	525.72	5.65	1122.68	27.00	2441.90	35.84
	7.50%	43-52-**65** (30%)	861.53	2.75	515.14	5.52	1399.88	24.90	2776.55	33.16
	10.00%	<43-52-**58**> (30%)	861.53	2.75	515.14	5.52	1040.07	19.25	2416.74	27.52
	12.50%	<43-52-**58**> (30%)	861.53	2.75	515.14	5.52	1040.07	19.25	2416.74	27.52
	15.0%	<43-52-**58**> (30%)	861.53	2.75	515.14	5.52	1040.07	19.25	2416.74	27.52

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for red maple plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	51-56-**76**[2] (30%)[3]	51-56-**76** (30%)	0%	51-58-**76** (30%)	0%	51-58-**76** (30%)	0%
	80	47-52-**67** (30%)	47-52-**67** (30%)	0%	47-52-**68** (30%)	1%	47-52-**68** (30%)	1%
	90	44-54-**66** (30%)	44-54-**66** (30%)	0%	44-54-**66** (30%)	0%	44-54-**66** (30%)	0%
5.00%	70	<41-51-**56**>[4] (20%)	<51-56-**66**> (20%)	18%	42-51-**64** (20%)	14%	51-61-**76** (25%)	36%
	80	<47-52-**65**> (30%)	<47-52-**65**> (30%)	0%	47-52-**66** (30%)	2%	47-52-**67** (30%)	3%
	90	<43-52-**58**> (30%)	43-52-**58** (30%)	0%	44-54-**66** (30%)	14%	44-54-**66** (30%)	14%
7.50%	70	<40-51-**56**> (20%)	<41-51-**56**> (20%)	0%	<42-51-**64**> (20%)	14%	<42-51-**64**> (20%)	14%
	80	<30-46-**51**> (30%)	<37-46-**57**> (30%)	12%	<47-52-**65**> (30%)	27%	47-52-**66** (30%)	29%
	90	<32-43-**51**> (25%)	<35-43-**51**> (25%)	0%	43-52-**58** (30%)	14%	43-52-**65** (30%)	27%
10.00%	70	<34-**50**> (30%)	<41-51-**56**> (20%)	12%	<41-51-**56**> (20%)	12%	<42-51-**64**> (20%)	28%
	80	<30-46-**51**> (30%)	<37-46-**52**> (30%)	2%	<40-47-**57**> (20%)	12%	<47-52-**65**> (30%)	27%
	90	<30-43-**51**> (25%)	<35-43-**51**> (25%)	0%	<35-44-**52**> (25%)	2%	<43-52-**58**> (30%)	14%
12.50%	70	<34-**50**> (30%)	<40-**51**> (25%)	2%	<41-51-**56**> (20%)	12%	<42-51-**64**> (20%)	28%
	80	<30-46-**51**> (30%)	<37-46-**52**> (30%)	2%	<40-47-**57**> (20%)	12%	<40-47-**57**> (20%)	12%
	90	<30-**43**> (30%)	<35-43-**51**> (25%)	19%	<37-43-**52**> (25%)	21%	<43-52-**58**> (30%)	35%
15.00%	70	<34-**50**> (30%)	<40-**50**> (30%)	0%	<41-51-**56**> (20%)	12%	<42-51-**64**> (20%)	28%
	80	<30-35-**46**> (30%)	<36-**46**> (25%)	0%	<40-46-**57**> (20%)	24%	<40-47-**57**> (20%)	24%
	90	<30-**43**> (30%)	<35-**43**> (20%)	0%	<37-43-**52**> (25%)	21%	<43-52-**58**> (30%)	35%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3] Number in parentheses indicates the percentage of basal area removed during thinning

[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for red maple plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	351.68	557.66	59%	1,115.08	217%	1,384.03	294%
	80	553.60	795.20	44%	1,448.12	162%	1,763.43	219%
	90	776.11	1,064.10	37%	1,841.68	137%	2,216.07	186%
5.00%	70	-250.16	-145.43		142.46		283.71	
	80	-194.80	-65.48		284.64		453.57	
	90	-143.17	10.26		433.45		638.28	
7.50%	70	-345.61	-282.93		-113.16		-29.50	
	80	-327.20	-251.65		-39.18		64.58	
	90	-307.59	-213.80		42.55		169.27	
10.00%	70	-368.27	-328.97		-220.28		-167.50	
	80	-361.00	-312.11		-174.06		-106.71	
	90	-354.51	-292.06		-121.73		-38.44	
12.50%	70	-374.07	-347.85		-274.74		-239.45	
	80	-371.31	-337.43		-242.87		-196.85	
	90	-368.83	-325.60		-207.10		-149.39	
15.00%	70	-375.52	-356.92		-305.63		-280.87	
	80	-374.17	-349.92		-282.42		-249.66	
	90	-373.10	-342.13		-256.64		-215.14	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

Central States- Red maple - Timber Only Rotations (C = $0/ton)

Red maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 5). This optimal management regime will generate the maximum SEV of $351.68 (Table 13), with a NPW of $299.15 per acre (Table 9). This means that $351.68 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $299.15 per acre for managing one rotation, or $351.68 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 1,906.67 cubic feet of pulpwood and 30.66 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.15 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 5). This optimal management regime will generate the maximum SEV of -$250.16 (Table 13), with a NPW of -$234.65 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,517.02 cubic feet of pulpwood and 15.84 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.47 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 5). This optimal management regime will generate the maximum SEV of -$345.61 (Table 13), with a NPW of -$340.00 per acre (Table 9). This financially optimal rotation would produce an estimated 2,478.64 cubic feet of pulpwood and 15.84 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.33 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 50 (Table 5). This optimal management regime will generate the maximum SEV of -$368.27 (Table 13), with a NPW of -$365.42 per acre (Table 9). This financially optimal rotation would produce an estimated 2,649.52 cubic feet of pulpwood and 9.80 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 17.29 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 50 (Table 5). This optimal management regime will generate the maximum SEV of -$374.07 (Table 13), with a NPW of -$373.15 per acre (Table 9). This financially optimal rotation would produce an estimated 2,649.52 cubic feet of pulpwood and 9.80 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 17.29 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 50 (Table 5). This optimal management regime will generate the maximum SEV of -$375.52 (Table 13), with a NPW of -$375.21 per acre (Table 9). This financially optimal rotation would produce an estimated 2,649.52 cubic feet of pulpwood and 9.80 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 17.29 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 5). This optimal management regime will generate the maximum SEV of $553.60 (Table 13), with a NPW of $450.33 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,399.21 cubic feet of pulpwood and 29.90 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 25.28 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 5). This optimal management regime will generate the maximum SEV of -$194.80 (Table 13), with a NPW of -$187.02 per acre (Table 9). This financially optimal rotation would produce an estimated 2,060.11 cubic feet of pulpwood and 28.65 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 24.59 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 5). This optimal management regime will generate the maximum SEV of -$327.20 (Table 13), with a NPW of -$319.58 per acre (Table 9). This financially optimal rotation would produce an estimated 2,792.67 cubic feet of pulpwood and 15.05 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 20.97 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 5). This optimal management regime will generate the maximum SEV of -$361.00 (Table 13), with a NPW of -$358.45 per acre (Table 9). This financially optimal rotation would produce an estimated 2,792.67 cubic feet of pulpwood and 15.05 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 20.97 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 5). This optimal management regime will generate the maximum SEV of -$371.31 (Table 13), with a NPW of -$370.50 per acre (Table 9). This financially optimal rotation would produce an estimated 2,792.67 cubic feet of pulpwood and 15.05 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 20.97 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 5). This optimal management regime will generate the maximum SEV of -$374.17 (Table 13), with a NPW of -$373.65 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,924.39 cubic feet of pulpwood and 8.13 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 18.70 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 5). This optimal management regime will generate the maximum SEV of $776.11 (Table 13), with a NPW of $627.71 per acre (Table 9). This financially optimal rotation would produce an estimated 2,441.90 cubic feet of pulpwood and 35.84 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 29.25 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 5). This optimal management regime will generate the maximum SEV of -$143.17 (Table 13), with a NPW of -$135.12 per acre (Table 9). This financially optimal rotation would produce an estimated 2,416.74 cubic feet of pulpwood and 27.52 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 26.26 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 43 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 5). This optimal management regime will generate the maximum SEV of -$307.59 (Table 13), with a NPW of -$300.43 per acre (Table 9). This financially optimal rotation would produce an estimated 3,042.32 cubic feet of pulpwood and 20.33 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 25.49 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 43 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 5). This optimal management regime will generate the maximum SEV of -$354.51 (Table 13), with a NPW of -$352.01 per acre (Table 9). This financially optimal rotation would produce an estimated 2,954.16 cubic feet of pulpwood and 20.24 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 25.03 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 30 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 43 (Table 5). This optimal management regime will generate the maximum SEV of -$368.83 (Table 13), with a NPW of -$366.76 per acre (Table 9). This financially optimal rotation would

produce an estimated 3,154.92 cubic feet of pulpwood and 9.73 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 20.70 net tons of carbon per acre during one rotation (Table 1).

Red maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 30 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 43 (Table 5). This optimal management regime will generate the maximum SEV of -$373.10 (Table 13), with a NPW of -$372.30 per acre (Table 9). This financially optimal rotation would produce an estimated 3,154.92 cubic feet of pulpwood and 9.73 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 20.70 net tons of carbon per acre during one rotation (Table 1).

<u>Central States- Red maple - Timber Only Rotations (C = $10/ton)</u>

Red maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 6). This optimal management regime will generate the maximum SEV of $557.66 (Table 14), with a NPW of $474.36 per acre (Table 10). This means that $557.66 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on

every dollar invested plus $474.36 per acre for managing one rotation, or $557.66 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 1,906.67 cubic feet of pulpwood and 30.66 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.15 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 56 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 6). This optimal management regime will generate the maximum SEV of -$145.43 (Table 14), with a NPW of -$139.89 per acre (Table 10). This financially optimal rotation would produce an estimated 1,979.90 cubic feet of pulpwood and 22.84 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 20.00 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 6). This optimal management regime will generate the maximum SEV of -$282.93 (Table 14), with a NPW of -$278.35 per acre (Table 10). This financially optimal rotation would produce an estimated 2,517.02 cubic feet of pulpwood and 15.84 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 19.47 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 6). This optimal management regime will generate the maximum SEV of -$328.97 (Table 14), with a NPW of -$327.53 per acre (Table 10). This financially optimal rotation would produce an estimated 2,517.02 cubic feet of pulpwood and 15.84 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.47 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 40 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 6). This optimal management regime will generate the maximum SEV of -$347.85 (Table 14), with a NPW of -$347.09 per acre (Table 10). This financially optimal rotation would produce an estimated 3,011.57 cubic feet of pulpwood and 10.66 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 18.30 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 40 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 50 (Table 6). This optimal management regime will generate the maximum SEV of -$356.92 (Table 14), with a NPW of -$356.63 per acre (Table 10). This financially optimal rotation would produce an estimated 2,942.48 cubic feet of pulpwood and 9.64 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 18.06 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 6). This optimal management regime will generate the maximum SEV of $795.20 (Table 14), with a NPW of $646.86 per acre (Table 10). This financially optimal rotation would produce an estimated 2,399.21 cubic feet of pulpwood and 29.89 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.28 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 6). This optimal management regime will generate the maximum SEV of -$65.48 (Table 14), with a NPW of -$62.86 per acre (Table 10). This financially optimal rotation would produce an estimated 2,060.11 cubic feet of pulpwood and 28.65 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 24.59 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 6). This optimal management regime will generate the maximum SEV of -$251.65 (Table 14), with a NPW of -$247.86 per acre (Table 10). This financially optimal rotation would produce an estimated 2,820.59 cubic feet of pulpwood and 20.27 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.95 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 6). This optimal management regime will generate the maximum SEV of -$312.11 (Table 14), with a NPW of -$310.11 per acre (Table 10). This financially optimal rotation would produce an estimated 3,177.04 cubic feet of pulpwood and 15.10 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.36 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 46 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 6). This optimal management regime will generate the maximum SEV of -$337.43 (Table 14), with a NPW of -$336.78 per acre (Table 10). This financially optimal rotation would produce an estimated 3,177.04 cubic feet of pulpwood and 15.10 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.36 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 36 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 6). This optimal management regime will generate the maximum SEV of -$349.92 (Table 14), with a NPW of -$349.43 per acre (Table 10). This financially optimal rotation would produce an estimated 2,944.86 cubic feet of pulpwood and 10.48 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.71 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 6). This optimal management regime will generate the maximum SEV of $1,064.10 (Table 14), with a NPW of $860.64 per acre (Table 10). This financially optimal rotation would produce an estimated 2,441.90 cubic feet of pulpwood and 35.84 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 29.25 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 6). This optimal management regime will generate the maximum SEV of $10.26 (Table 14), with a NPW of $9.68 per acre (Table 10). This financially optimal rotation would produce an estimated 2,416.74 cubic feet of pulpwood and 27.52 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.26 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 43 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 6). This optimal management regime will generate the maximum SEV of -$213.80 (Table 14), with a NPW of -$208.82 per acre (Table 10). This financially optimal rotation would produce an estimated 3,229.90 cubic feet of pulpwood and 20.11 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.91 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 43 (with 25

percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 6). This optimal management regime will generate the maximum SEV of -$292.06 (Table 14), with a NPW of -$290.00 per acre (Table 10). This financially optimal rotation would produce an estimated 3,229.90 cubic feet of pulpwood and 20.11 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.91 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 43 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 6). This optimal management regime will generate the maximum SEV of -$325.60 (Table 14), with a NPW of -$324.89 per acre (Table 10). This financially optimal rotation would produce an estimated 3,229.90 cubic feet of pulpwood and 20.11 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.91 net tons of carbon per acre during one rotation (Table 2).

Red maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 35 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 43 (Table 6). This optimal management regime will generate the maximum SEV of -$342.13 (Table 14), with a NPW of -$341.40 per acre (Table 10). This financially optimal rotation would produce an estimated 3,362.02 cubic feet of pulpwood and 10.65 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 21.80 net tons of carbon per acre during one rotation (Table 2).

Central States-Red maple - Timber Only Rotations (C = $37/ton)

Red maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 58 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 7). This optimal management regime will generate the maximum SEV of $1,115.08 (Table 15), with a NPW of $948.52 per acre (Table 11). This means that $1,115.08 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $948.52 per acre for managing one rotation, or $1,115.08 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 1,924.22 cubic feet of pulpwood and 30.71 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.25 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 51 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 7). This optimal management regime will generate the maximum SEV of $142.46 (Table 15), with a NPW of $136.49 per acre (Table 11). This financially optimal rotation would produce an estimated 2,074.77 cubic feet of pulpwood and 21.35 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 20.88 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 7). This optimal management regime will generate the maximum SEV of -$113.16 (Table 15), with a NPW of -$112.13 per acre (Table 11). This financially optimal rotation would produce an estimated 2,074.77 cubic feet of pulpwood and 21.35 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 20.88 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 7). This optimal management regime will generate the maximum SEV of -$220.28 (Table 15), with a NPW of -$219.32 per acre (Table 11). This financially optimal rotation would produce an estimated 2,517.02 cubic feet of pulpwood and 15.84 MBF of sawlogs

per acre from the thinning and final harvest (Table 19), and sequester 19.47 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 7). This optimal management regime will generate the maximum SEV of -$274.74 (Table 15), with a NPW of -$274.41 per acre (Table 11). This financially optimal rotation would produce an estimated 2,517.02 cubic feet of pulpwood and 15.84 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 19.47 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 7). This optimal management regime will generate the maximum SEV of -$305.63 (Table 15), with a NPW of -$305.52 per acre (Table 11). This financially optimal rotation would produce an estimated 2,517.02 cubic feet of pulpwood and 15.84 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 19.47 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 52 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 7). This optimal management regime will generate the maximum SEV of $1,448.12 (Table 15), with a NPW of $1,184.57 per acre (Table 11). This financially optimal rotation would produce an estimated 2,426.42 cubic feet of pulpwood and 30.43 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 25.61 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 7). This optimal management regime will generate the maximum SEV of $284.64 (Table 15), with a NPW of $273.81 per acre (Table 11). This financially optimal rotation would produce an estimated 2,253.38 cubic feet of pulpwood and 29.35 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 24.94 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 7). This optimal management regime will generate the maximum SEV of -$39.18 (Table 15), with a NPW of -$38.85 per acre (Table 11). This financially optimal rotation would produce an estimated 2,060.11 cubic feet of pulpwood and 28.65 MBF of sawlogs per

acre from the thinning and final harvest (Table 19), and sequester 24.59 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 47 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 7). This optimal management regime will generate the maximum SEV of -$174.06 (Table 15), with a NPW of $173.37 per acre (Table 11). This financially optimal rotation would produce an estimated 2,518.75 cubic feet of pulpwood and 21.28 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.07 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 47 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 7). This optimal management regime will generate the maximum SEV of -$242.87 (Table 15), with a NPW of -$242.61 per acre (Table 11). This financially optimal rotation would produce an estimated 2,518.75 cubic feet of pulpwood and 21.28 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.07 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 7). This optimal management regime will generate the maximum SEV of -$282.42 (Table 15), with a NPW of -$282.33 per acre (Table 11). This financially optimal rotation would produce an estimated 2,517.98 cubic feet of pulpwood and 21.13 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 22.96 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 7). This optimal management regime will generate the maximum SEV of $1,841.68 (Table 15), with a NPW of $1,489.54 per acre (Table 11). This financially optimal rotation would produce an estimated 2,441.90 cubic feet of pulpwood and 35.84 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 29.25 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 7). This optimal management regime will generate the maximum SEV of $433.45 (Table 15), with a NPW of $416.96 per acre (Table 11). This financially optimal rotation would produce an estimated 2,441.90 cubic feet of pulpwood and 35.84 MBF of sawlogs per

acre from the thinning and final harvest (Table 19), and sequester 29.25 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 7). This optimal management regime will generate the maximum SEV of $42.55 (Table 15), with a NPW of $41.96 per acre (Table 11). This financially optimal rotation would produce an estimated 2,416.74 cubic feet of pulpwood and 27.52 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.26 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 44 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 7). This optimal management regime will generate the maximum SEV of -$121.73 (Table 15), with a NPW of -$120.95 per acre (Table 11). This financially optimal rotation would produce an estimated 3,267.60 cubic feet of pulpwood and 21.06 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.63 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 43 (with 25

percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 7). This optimal management regime will generate the maximum SEV of -$207.10 (Table 15), with a NPW of -$206.70 per acre (Table 11). This financially optimal rotation would produce an estimated 3,259.14 cubic feet of pulpwood and 20.59 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.31 net tons of carbon per acre during one rotation (Table 3).

Red maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 43 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 7). This optimal management regime will generate the maximum SEV of -$256.64 (Table 15), with a NPW of -$256.48 per acre (Table 11). This financially optimal rotation would produce an estimated 3,259.14 cubic feet of pulpwood and 20.59 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.31 net tons of carbon per acre during one rotation (Table 3).

Central States- Red maple - Timber Only Rotations (C = $50/ton)

Red maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 58 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 8). This optimal management regime will generate the maximum SEV of $1,384.03 (Table 16), with a NPW of $1,177.30 per acre (Table 12). This means that $1,384.03 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,177.30 per acre for managing one rotation, or $1,384.03 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 1,924.22 cubic feet of pulpwood and 30.71 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.25 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 61 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 8). This optimal management regime will generate the maximum SEV of $283.71 (Table 16), with a NPW of $277.09 per acre (Table 12). This financially optimal rotation would produce an estimated 1,790.77 cubic feet of pulpwood and 30.10 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 22.36 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 8).

This optimal management regime will generate the maximum SEV of -$29.50 (Table 16), with a NPW of -$29.24 per acre (Table 12). This financially optimal rotation would produce an estimated 2,074.77 cubic feet of pulpwood and 21.35 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 20.88 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 8). This optimal management regime will generate the maximum SEV of -$167.50 (Table 16), with a NPW of -$167.15 per acre (Table 12). This financially optimal rotation would produce an estimated 2,074.77 cubic feet of pulpwood and 21.35 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 20.88 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 8). This optimal management regime will generate the maximum SEV of -$239.45 (Table 16), with a NPW of -$239.33 per acre (Table 12). This financially optimal rotation would produce an estimated 2,074.77 cubic feet of pulpwood and 21.35 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 20.88 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 8). This optimal management regime will generate the maximum SEV of -$280.87 (Table 16), with a NPW of -$280.83 per acre (Table 12). This financially optimal rotation would produce an estimated 2,074.77 cubic feet of pulpwood and 21.35 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 20.88 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 8). This optimal management regime will generate the maximum SEV of $1,763.43 (Table 16), with a NPW of $1,442.50 per acre (Table 12). This financially optimal rotation would produce an estimated 2,426.42 cubic feet of pulpwood and 30.43 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.61 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 8). This optimal management regime will generate the maximum SEV of $453.57 (Table

16), with a NPW of $437.13 per acre (Table 12). This financially optimal rotation would produce an estimated 2,399.21 cubic feet of pulpwood and 29.90 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.28 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 8). This optimal management regime will generate the maximum SEV of $64.58 (Table 16), with a NPW of $64.08 per acre (Table 12). This financially optimal rotation would produce an estimated 2,253.38 cubic feet of pulpwood and 29.35 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 24.94 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 8). This optimal management regime will generate the maximum SEV of -$106.71 (Table 16), with a NPW of -$106.51 per acre (Table 12). This financially optimal rotation would produce an estimated 2,060.11 cubic feet of pulpwood and 28.65 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 24.59 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 47 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 8). This optimal management regime will generate the maximum SEV of -$196.85 (Table 16), with a NPW of -$196.64 per acre (Table 12). This financially optimal rotation would produce an estimated 2,518.75 cubic feet of pulpwood and 21.28 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.07 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 47 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 8). This optimal management regime will generate the maximum SEV of -$249.66 (Table 16), with a NPW of -$249.58 per acre (Table 12). This financially optimal rotation would produce an estimated 2,518.75 cubic feet of pulpwood and 21.28 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.07 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 8). This optimal management regime will generate the maximum SEV of $2,216.07 (Table 16), with a NPW of $1,792.34 per acre (Table 12). This financially optimal rotation

would produce an estimated 2,441.90 cubic feet of pulpwood and 35.84 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.25 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 8). This optimal management regime will generate the maximum SEV of $638.28 (Table 16), with a NPW of $614.00 per acre (Table 12). This financially optimal rotation would produce an estimated 2,441.90 cubic feet of pulpwood and 35.84 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.25 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 8). This optimal management regime will generate the maximum SEV of $169.27 (Table 16), with a NPW of $167.84 per acre (Table 12). This financially optimal rotation would produce an estimated 2,776.55 cubic feet of pulpwood and 33.16 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.17 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 8). This optimal management regime will generate the maximum SEV of -$38.44 (Table 16), with a NPW of -$38.30 per acre (Table 12). This financially optimal rotation would produce an estimated 2,416.74 cubic feet of pulpwood and 27.52 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 26.26 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 8). This optimal management regime will generate the maximum SEV of -$149.39 (Table 16), with a NPW of -$149.25 per acre (Table 12). This financially optimal rotation would produce an estimated 2,416.74 cubic feet of pulpwood and 27.52 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 26.26 net tons of carbon per acre during one rotation (Table 4).

Red maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 8). This optimal management regime will generate the maximum SEV of -$215.14 (Table 16), with a NPW of -$215.08 per acre (Table 12). This financially optimal rotation

would produce an estimated 2,416.74 cubic feet of pulpwood and 27.52 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 26.26 net tons of carbon per acre during one rotation (Table 4).

Species ___red maple_________ Region ______Lake States_________________

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 8.40, 10.40, and 12.50 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 25 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183553598 and 0.489476260, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Crow and Erdmann (1984) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$\text{Ln}Y = 1.245 + 2.334 \ln(DBH)$$

where:

Y = Total tree dry weight (lb.)

DBH = diameter at breast height (in.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be \$120/mbf (International 1/4) (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005) and pulpwood price was assumed to be \$17/cord (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005). The price of carbon was assumed to be \$0, \$10, \$37 or \$50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of red maple plantations in the Lake States.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$130.80	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]The seedling cost was estimated based on the seedling prices from Minnesota DNR State Forest Nursery (http://www.dnr.state.mn.us/forestry/nurseries/pricelist.html. January 18, 2006) and Lee's Nursery, Inc. (http://www.leenursery.com/Seedling2006Catalog.pdf. January 18, 2006).

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Table 23. Total tons of carbon sequestered per acre for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	36.20	30.72	30.72	30.72	28.84	28.84
80	27.16	24.77	22.27	22.27	22.27	22.27
90	42.15	36.26	32.01	29.60	29.04	29.04

[1]Base age 50.

Table 24. Total tons of carbon sequestered per acre for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	39.07	35.83	30.72	30.72	30.72	30.72
80	27.16	30.76	30.76	30.69	30.69	30.69
90	42.15	37.61	33.26	32.50	29.41	29.41

[1]Base age 50.

Table 25. Total tons of carbon sequestered per acre for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	41.60	41.60	37.81	38.08	38.01	33.16
80	34.52	34.52	32.28	32.28	32.49	32.49
90	42.15	44.39	39.69	38.06	38.06	39.64

[1]Base age 50.

Table 26. Total tons of carbon sequestered per acre for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	41.60	41.60	38.04	38.27	33.16	27.88
80	34.52	35.71	33.34	33.67	35.58	34.07
90	44.39	44.39	38.06	38.06	41.67	41.67

[1]Base age 50.

Table 27. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	<34-68-**79**[2]>[3] (30%)[4]	<33-39-**63**> (30%)	<33-39-**63**> (30%)	<33-39-**63**> (30%)	<33-39-**58**> (30%)	<33-39-**58**> (30%)
80	27-59-**79** (30%)	<26-33-**64**> (30%)	<26-33-**55**> (30%)	<26-33-**55**> (30%)	<26-33-**55**> (30%)	<26-33-**55**> (30%)
90	29-54-**79** (30%)	<27-33-**56**> (30%)	<25-30-**55**> (30%)	<25-31-**49**> (30%)	<25-30-**48**> (30%)	<25-30-**48**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 28. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	34-68-**85**[2] (30%)[3]	<33-40-**75**>[4] (30%)	<33-39-**63**> (30%)	<33-39-**63**> (30%)	<33-39-**63**> (30%)	<33-39-**63**> (30%)
80	27-59-**79** (30%)	<26-**60**> (30%)	<26-**60**> (30%)	<26-**59**> (30%)	<26-**59**> (30%)	<26-**59**> (30%)
90	29-54-**79** (30%)	<29-54-**67**> (30%)	<27-33-**56**> (30%)	<27-33-**55**> (30%)	<27-32-**49**> (30%)	<27-32-**49**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 29. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	48-72-**90**[2] (30%)[3]	48-72-**90**[2] (30%)[3]	48-67-**89** (20%)	<50-68-**87**> (20%)	<50-68-**87**> (20%)	<71-**90**> (20%)
80	43-**73** (30%)	43-**73** (30%)	43-**76** (20%)	43-**76** (20%)	<50-**76**> (20%)	<50-**76**> (20%)
90	29-54-**79** (30%)	39-60-**83** (30%)	39-58-**73** (25%)	39-58-**74** (20%)	<39-58-**74**> (20%)	<60-66-**82**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 30. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	48-72-**90**[2] (30%)[3]	48-72-**90**[2] (30%)[3]	48-67-**89** (20%)	50-68-**90** (20%)	<71-**90>** (20%)	<**90**> (0%)
80	43-**73** (30%)	43-**87** (30%)	43-**89** (20%)	50-**89** (20%)	68-**90** (25%)	<68-**89**> (20%)
90	39-60-**83** (30%)	39-60-**83** (30%)	39-58-**74** (20%)	39-58-**74** (20%)	60-67-**88** (30%)	<60-67-**88>** (30%)

[1] Base age 50.
[2] Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3] Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4] Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 31. Net present worth of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$85.70	-$315.96	-$361.91	-$373.06	-$375.47	-$375.94
80	$21.73	-$283.62	-$346.22	-$365.77	-$372.06	-$374.14
90	$125.11	-$249.80	-$335.95	-$359.80	-$370.90	-$372.74

[1]Base age 50.

Table 32. Net present worth of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$201.48	-$142.50	-$240.02	-$283.46	-$307.32	-$322.26
80	$257.09	-$108.31	-$219.59	-$269.51	-$296.92	-$314.10
90	$332.42	-$51.54	-$191.29	-$252.91	-$285.19	-$305.52

[1]Base age 50.

Table 33. Net present worth of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,023.08	$374.71	$107.59	-$33.48	-$119.03	-$175.27
80	$1,046.01	$442.17	$164.18	$11.01	-$83.62	-$146.54
90	$1,355.08	$551.32	$224.80	$55.13	-$49.11	-$118.70

[1]Base age 50.

Table 34. Net present worth of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,423.65	$628.05	$277.82	$87.94	-$27.96	-$104.34
80	$1,439.24	$723.02	$354.15	$147.83	$19.84	-$65.52
90	$1,825.59	$850.93	$431.32	$206.36	$66.11	-$27.94

[1]Base age 50.

Table 35. Soil expectation value of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$99.50	-$330.52	-$365.48	-$373.90	-$375.83	-$376.04
80	$25.23	-$296.04	-$352.36	-$367.54	-$372.57	-$374.29
90	$145.26	-$266.30	-$341.91	-$362.90	-$370.32	-$373.14

[1]Base age 50.

Table 36. Soil expectation value of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$228.85	-$146.08	-$242.39	-$284.10	-$307.48	-$322.30
80	$298.49	-$114.13	-$222.29	-$270.40	-$297.18	-$314.17
90	$531.22	-$53.48	-$194.44	-$254.13	-$285.98	-$305.80

[1]Base age 50.

Table 37. Soil expectation value of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,144.02	$379.18	$107.79	-$33.49	-$119.04	-$175.27
80	$1,246.52	$454.45	$164.81	$11.02	-$83.63	-$146.54
90	$1,573.30	$560.63	$225.87	$55.18	-$49.11	-$118.70

[1]Base age 50.

Table 38. Soil expectation value of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the lake states region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,591.94	$635.55	$278.24	$87.95	-$27.96	-$104.34
80	$1,715.12	$733.03	$354.68	$147.86	$19.84	-$65.52
90	$2,087.96	$865.29	$433.23	$206.52	$66.12	-$27.94

[1]Base age 50.

Table 39. Volume removed from the financially optimal schedules for red maple plantations by soil productivity and real alternative rates of return in the lake states region). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	34-68-**79** (30%)	636.19	0	664.94	2.67	1,279.08	10.62		
	5.0%	33-39-**63** (30%)	593.88	0	555.66	0	1,777.79	7.16		
	7.5%	33-39-**63** (30%)	593.88	0	555.66	0	1,777.79	7.16		
	10.0%	33-39-**63** (30%)	593.88	0	555.66	0	1,777.79	7.16		
	12.5%	33-39-**58** (30%)	593.88	0	555.66	0	2,233.49	4.05		
	15.0%	33-39-**58** (30%)	593.88	0	555.66	0	2,233.49	4.05		
80	2.5%	27-59-**79** (30%)	571.86	0	655.35	2.60	1,305.60	15.58		
	5.0%	26-33-**64** (30%)	560.33	0	637.06	0	1,843.97	11.66		
	7.5%	26-33-**55** (30%)	560.33	0	637.06	0	1,865.87	7.11		
	10.0%	26-33-**55** (30%)	560.33	0	637.06	0	1,865.87	7.11		
	12.5%	26-33-**55** (30%)	560.33	0	637.06	0	1,865.87	7.11		
	15.0%	26-33-**55** (30%)	560.33	0	637.06	0	1,865.87	7.11		
90	2.5%	29-54-**79** (30%)	767.03	0	757.13	2.52	1,242.97	20.19		
	5.0%	27-33-**56** (30%)	716.30	0	649.70	0	2,061.93	10.87		
	7.5%	25-30-**55** (30%)	579.54	0	614.86	0	2,023.08	10.38		
	10.0%	25-31-**49** (30%)	579.54	0	641.12	0	2,086.05	6.94		
	12.5%	25-30-**48** (30%)	579.54	0	614.86	0	2,248.75	5.96		
	15.0%	25-30-**48** (30%)	579.54	0	614.86	0	2,248.75	5.96		

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 40. Volume removed from the financially optimal schedules for red maple plantations by soil productivity and real alternative rates of return in the lake states region. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	34-68-**85** (30%)	636.19	0	664.94	2.670	1,414.00	11.98		
	5.0%	33-40-**75** (30%)	593.88	0	573.91	0	1,457.27	12.07		
	7.5%	33-39-**63** (30%)	593.88	0	555.66	0	1,777.79	7.16		
	10.0%	33-39-**63** (30%)	593.88	0	555.66	0	1,777.79	7.16		
	12.5%	33-39-**63** (30%)	593.88	0	555.66	0	1,777.79	7.16		
	15.0%	33-39-**63** (30%)	593.88	0	555.66	0	1,777.79	7.16		
80	2.5%	27-59-**79** (30%)	571.86	0	655.35	2.600	1,305.60	15.58		
	5.0%	26-**60** (30%)	560.30	0	-	-	2,303.14	8.86		
	7.5%	26-**60** (30%)	560.30	0	-	-	2,303.14	8.86		
	10.0%	26-**59** (30%)	560.30	0	-	-	2,355.36	8.21		
	12.5%	26-**59** (30%)	560.30	0	-	-	2,355.36	8.21		
	15.0%	26-**59** (30%)	560.30	0	-	-	2,355.36	8.21		
90	2.5%	29-54-**79** (30%)	767.03	0	757.13	2.520	1,242.97	20.19		
	5.0%	29-54-**67** (30%)	767.03	0	757.13	0	1,562.81	14.19		
	7.5%	27-33-**56** (30%)	716.30	0	649.70	0	2,061.93	10.87		
	10.0%	27-32-**55** (30%)	716.30	0	624.91	0	2,008.74	9.99		
	12.5%	27-32-**49** (30%)	716.30	0	642.91	0	2,053.69	6.64		
	15.0%	27-32-**49** (30%)	716.30	0	642.91	0	2,053.69	6.64		

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 41. Volume removed from the financially optimal schedules for red maple plantations by soil productivity and real alternative rates of return in the lake states region. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	48-72-**90** (30%)	964.44	0	662.56	2.67	1,434.60	12.21		
	5.0%	48-72-**90** (30%)	964.44	0	662.56	2.67	1,434.60	12.21		
	7.5%	48-67-**86** (20%)	630.56	0	519.22	9.93	1,535.55	12.76		
	10.0%	50-68-**87** (20%)	675.18	0	503.98	1.08	1,536.67	12.81		
	12.5%	50-68-**87** (20%)	675.18	0	503.98	1.08	1,536.67	12.81		
	15.0%	71-**90** (20%)	521.68	0.98	-	-	1,527.66	12.77		
80	2.5%	43-**73** (30%)	997.24	0	-	-	2,014.53	12.31		
	5.0%	43-**73** (30%)	997.24	0	-	-	2,014.53	12.31		
	7.5%	43-**79**(20%)	664.75	0	-	-	1,977.81	12.53		
	10.0%	43-**79**(20%)	664.75	0	-	-	1,977.81	12.53		
	12.5%	50-**76** (20%)	768.72	0	-	-	1,976.50	12.52		
	15.0%	50-**76** (20%)	768.72	0	-	-	1,976.50	12.52		
90	2.5%	29-54-**79** (30%)	767.03	0		2.53	1,242.97	20.19		
	5.0%	39-60-**83** (30%)	1111.13	0		2.68	1,242.74	20.19		
	7.5%	39-58-**73** (25%)	926.04	0		2.20	1,707.28	15.58		
	10.0%	39-58-**74** (20%)	740.78	0		1.75	1,765.97	16.08		
	12.5%	39-58-**74** (20%)	740.78	0		1.75	1,765.97	16.08		
	15.0%	60-66-**82** (30%)	833.00	2.43		3.01	1,370.79	15.37		

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indiates no operation conducted

Table 42. Volume removed from the financially optimal schedules for red maple plantations by soil productivity and real alternative rates of return in the lake states region. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	48-72-**90** (30%)	964.44	0	662.56	2.67	1,434.60	12.21		
	5.0%	48-72-**90** (30%)	964.44	0	662.56	2.67	1,434.60	12.21		
	7.5%	48-67-**89** (20%)	630.56	0	519.22	0.99	1,538.08	12.91		
	10.0%	50-68-**90** (20%)	675.18	0	503.98	1.08	1,539.39	12.95		
	12.5%	71-**90** (20%)	521.68	0.98	-	-	1,527.66	12.77		
	15.0%	**90** (0%)	-	-	-	-	1,723.88	11.83		
80	2.5%	43-**73** (30%)	997.24	0	-	-	2,014.53	12.31		
	5.0%	43-**87** (30%)	997.24	0	-	-	1,378.88	16.49		
	7.5%	43-**89** (20%)	664.75	0	-	-	1,418.35	16.27		
	10.0%	50-**89** (20%)	768.72	0	-	-	1,433.37	16.18		
	12.5%	68-**90** (25%)	568.37	2.14	-	-	1,381.44	16.61		
	15.0%	68-**89** (20%)	457.61	1.70	-	-	1,394.41	16.42		
90	2.5%	39-60-**83** (30%)	1,111.31	0	791.07	2.68	1,242.74	20.19		
	5.0%	39-60-**83** (30%)	1,111.31	0	791.07	2.68	1,242.74	20.19		
	7.5%	39-58-**74** (20%)	740.78	0	526.82	1.75	1,765.97	16.08		
	10.0%	39-58-**74** (20%)	740.78	0	526.82	1.75	1,765.97	16.08		
	12.5%	60-67-**88** (30%)	833.00	2.43	567.00	3.10	1,438.08	18.48		
	15.0%	60-67-**88** (30%)	833.00	2.43	567.00	3.10	1,438.08	18.48		

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted

Table 43. Financially optimal thinning and final harvest schedules for red maple plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	<34-68-**79**[2]>[3] (30%)[4]	34-68-**85** (30%)	8%	48-72-**90** (30%)	14%	48-72-**90** (30%)	14%
	80	27-59-**79** (30%)	27-59-**79** (30%)	0%	43-**73** (30%)	-8%	43-**73** (30%)	-8%
	90	29-54-**79** (30%)	29-54-**79** (30%)	0%	29-54-**79** (30%)	0%	39-60-**83** (30%)	5%
5.00%	70	<33-39-**63**> (30%)	<33-40-**75**> (30%)	19%	48-72-**90** (30%)	43%	48-72-**90** (30%)	43%
	80	<26-33-**64>** (30%)	<26-**60>** (30%)	-6%	43-**73** (30%)	14%	43-**87** (30%)	36%
	90	<27-33-**56**> (30%)	<29-54-**67**> (30%)	20%	39-60-**83** (30%)	48%	39-60-**83** (30%)	48%
7.50%	70	<33-39-**63**> (30%)	<33-39-**63**> (30%)	15%	48-67-**89** (20%)	62%	48-67-**89** (20%)	62%
	80	<26-33-**55**> (30%)	<26-**60**> (30%)	9%	43-**76** (20%)	38%	43-**89** (20%)	62%
	90	<25-30-**55**> (30%)	<27-33-**56**> (30%)	2%	39-58-**73** (25%)	33%	39-58-**74** (20%)	35%
10.00%	70	<33-39-**63**> (30%)	<33-39-**63**> (30%)	0%	<50-68-**87**> (20%)	38%	50-68-**90** (20%)	43%
	80	<26-33-**55**> (30%)	<26-**59**> (30%)	7%	43-**76** (20%)	38%	50-**89** (20%)	62%
	90	<25-31-**49**> (30%)	<27-33-**55**> (30%)	-5%	39-58-**74** (20%)	28%	39-58-**74** (20%)	28%
12.50%	70	<33-39-**58**> (30%)	<33-39-**63**> (30%)	9%	<50-68-**87**> (20%)	50%	<71-**90>** (20%)	55%
	80	<26-33-**55**> (30%)	<26-**59**> (30%)	7%	<50-**76**> (20%)	38%	68-**90** (25%)	64%
	90	<25-30-**48**> (30%)	<27-32-**49**> (30%)	2%	<39-58-**74**> (20%)	54%	60-67-**88** (30%)	83%
15.00%	70	<33-39-**58**> (30%)	<33-39-**63**> (30%)	9%	<71-**90**> (20%)	55%	<**90**>	55%
	80	<26-33-**55**> (30%)	<26-**59**> (30%)	7%	<50-**76**> (20%)	38%	<68-**89**> (20%)	62%
	90	<25-30-**48**> (30%)	<27-32-**49**> (30%)	2%	<60-66-**82>** (30%)	71%	<60-67-**88>** (30%)	83%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning

Table 44. The soil expectation value ($/acre) of the financially optimal rotations for red maple plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	-99.50	228.85		1,144.02		1,591.94	
	80	25.23	298.49	1083%	1,246.52	4841%	1,715.12	6698%
	90	145.26	531.22	266%	1,573.30	983%	2,087.96	1337%
5.00%	70	-330.52	-146.08		379.18		635.55	
	80	-296.04	-114.13		454.45		733.03	
	90	-266.30	-53.48		560.63		865.29	
7.50%	70	-365.48	-242.39		107.79		278.24	
	80	-352.36	-222.29		164.81		354.68	
	90	-341.91	-194.44		225.87		433.23	
10.00%	70	-373.90	-284.10		-33.49		87.95	
	80	-367.54	-270.40		11.02		147.86	
	90	-362.90	-254.13		55.18		206.52	
12.50%	70	-375.83	-307.48		-119.04		-27.96	
	80	-372.57	-297.18		-83.63		19.84	
	90	-370.32	-285.98		-49.11		66.12	
15.00%	70	-376.04	-322.30		-175.27		-104.34	
	80	-374.29	-314.17		-146.54		-65.52	
	90	-373.14	-305.80		-118.70		-27.94	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

Lake States- Red maple - Timber Only Rotations (C = $0/ton)

Red maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 68 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 27). This optimal management regime will generate the maximum SEV of -$99.50 (Table 35), with a NPW of -$85.70 per acre (Table 31). This means that -$99.50 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$85.70 per acre for managing one rotation, or -$99.50 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,580.21 cubic feet of pulpwood and 13.29 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 36.20 net tons of carbon per acre during one rotation (Table 23). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 63 (Table 27). This optimal management regime will generate the maximum SEV of -$330.52 (Table 35), with a NPW of -$315.96 per acre (Table 31). This financially optimal

rotation would produce an estimated 2,927.33 cubic feet of pulpwood and 7.16 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 30.72 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 63 (Table 27). This optimal management regime will generate the maximum SEV of -$365.48 (Table 35), with a NPW of -$361.91 per acre (Table 31). This financially optimal rotation would produce an estimated 2,927.33 cubic feet of pulpwood and 7.16 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 30.72 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 63 (Table 27). This optimal management regime will generate the maximum SEV of -$373.90 (Table 35), with a NPW of -$373.06 per acre (Table 31). This financially optimal rotation would produce an estimated 2,927.33 cubic feet of pulpwood and 7.16 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 30.72 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 27). This optimal management regime will generate the maximum SEV of -$375.83 (Table 35), with a NPW of -$375.47 per acre (Table 31). This financially optimal rotation would produce an estimated 3,383.03 cubic feet of pulpwood and 4.05 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 28.84 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 27). This optimal management regime will generate the maximum SEV of -$376.04 (Table 35), with a NPW of -$375.94 per acre (Table 31). This financially optimal rotation would produce an estimated 3,383.03 cubic feet of pulpwood and 4.05 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 28.84 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 59 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 27). This optimal management regime will generate the maximum SEV of $25.23 (Table 35), with a NPW of $21.73 per acre (Table 31). This financially optimal rotation would

produce an estimated 2,532.81 cubic feet of pulpwood and 18.18 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 27.16 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 33 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 27). This optimal management regime will generate the maximum SEV of -$296.04 (Table 35), with a NPW of -$283.62 per acre (Table 31). This financially optimal rotation would produce an estimated 3,041.36 cubic feet of pulpwood and 11.66 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 24.77 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 33 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 27). This optimal management regime will generate the maximum SEV of -$352.36 (Table 35), with a NPW of -$346.22 per acre (Table 31). This financially optimal rotation would produce an estimated 3,063.26 cubic feet of pulpwood and 7.11 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 22.27 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 33 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 27). This optimal management regime will generate the maximum SEV of -$367.54 (Table 35), with a NPW of -$365.77 per acre (Table 31). This financially optimal rotation would produce an estimated 3,063.26 cubic feet of pulpwood and 7.11 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 22.27 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 33 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 27). This optimal management regime will generate the maximum SEV of -$372.57 (Table 35), with a NPW of -$372.06 per acre (Table 31). This financially optimal rotation would produce an estimated 3,063.26 cubic feet of pulpwood and 7.11 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 22.27 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 33 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 27). This optimal management regime will generate the maximum SEV of -$374.29 (Table 35), with a NPW of -$374.14 per acre (Table 31). This financially optimal

rotation would produce an estimated 3,063.26 cubic feet of pulpwood and 7.11 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 22.27 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 27). This optimal management regime will generate the maximum SEV of $145.26 (Table 35), with a NPW of $125.11 per acre (Table 31). This financially optimal rotation would produce an estimated 2,767.13 cubic feet of pulpwood and 22.71 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 42.15 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 33 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 27). This optimal management regime will generate the maximum SEV of -$266.30 (Table 35), with a NPW of -$249.80 per acre (Table 31). This financially optimal rotation would produce an estimated 3,427.93 cubic feet of pulpwood and 10.87 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 36.26 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 30 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 27). This optimal management regime will generate the maximum SEV of -$341.91 (Table 35), with a NPW of -$335.95 per acre (Table 31). This financially optimal rotation would produce an estimated 3,217.48 cubic feet of pulpwood and 10.38 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 32.01 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 27). This optimal management regime will generate the maximum SEV of -$362.90 (Table 35), with a NPW of -$359.80 per acre (Table 31). This financially optimal rotation would produce an estimated 3,306.71 cubic feet of pulpwood and 6.94 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 29.60 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 30 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 48 (Table 27). This optimal management regime will generate the maximum SEV of -$370.90 (Table 35), with a NPW of -$370.32 per acre (Table 31). This financially optimal

rotation would produce an estimated 3,443.15 cubic feet of pulpwood and 5.96 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 29.04 net tons of carbon per acre during one rotation (Table 23).

Red maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 30 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 48 (Table 27). This optimal management regime will generate the maximum SEV of -$373.14 (Table 35), with a NPW of -$372.74 per acre (Table 31). This financially optimal rotation would produce an estimated 3,443.15 cubic feet of pulpwood and 5.96 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 29.04 net tons of carbon per acre during one rotation (Table 23).

Lake States- Red maple - Timber Only Rotations (C = $10/ton)

Red maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 68 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 28). This optimal management regime will generate the maximum SEV of $228.85 (Table 36), with a NPW of $201.48 per acre (Table 32). This means that $228.85 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on

every dollar invested plus $201.48 per acre for managing one rotation, or $228.85 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,715.13 cubic feet of pulpwood and 14.65 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 39.07 net tons of carbon per acre during one rotation (Table 24). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 28). This optimal management regime will generate the maximum SEV of -$146.08 (Table 36), with a NPW of -$142.50 per acre (Table 32). This financially optimal rotation would produce an estimated 2,625.06 cubic feet of pulpwood and 12.07 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 35.83 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 63 (Table 28). This optimal management regime will generate the maximum SEV of -$242.39 (Table 36), with a NPW of -$240.02 per acre (Table 32). This financially optimal rotation would produce an estimated 2,927.33 cubic feet of pulpwood and 7.16 MBF of

sawlogs per acre from the thinning and final harvest (Table 40), and sequester 30.72 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 63 (Table 28). This optimal management regime will generate the maximum SEV of -$284.10 (Table 36), with a NPW of -$283.46 per acre (Table 32). This financially optimal rotation would produce an estimated 2,927.33 cubic feet of pulpwood and 7.16 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 30.72 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 63 (Table 28). This optimal management regime will generate the maximum SEV of -$307.48 (Table 36), with a NPW of -$307.32 per acre (Table 32). This financially optimal rotation would produce an estimated 2,927.33 cubic feet of pulpwood and 7.16 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 30.72 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 39 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 63 (Table 28). This optimal management regime will generate the maximum SEV of -$322.30 (Table 36), with a NPW of -$322.76 per acre (Table 32). This financially optimal rotation would produce an estimated 2,927.33 cubic feet of pulpwood and 7.16 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 30.72 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 59 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 28). This optimal management regime will generate the maximum SEV of $298.49 (Table 36), with a NPW of $257.09 per acre (Table 32). This financially optimal rotation would produce an estimated 2,532.81 cubic feet of pulpwood and 18.18 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 27.16 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 28). This optimal management regime will generate the maximum SEV of -$114.13 (Table 36), with a NPW of -$108.31 per acre (Table 32). This financially optimal rotation would produce an estimated 2,863.44 cubic feet of pulpwood and 8.86 MBF of sawlogs per acre

from the thinning and final harvest (Table 40), and sequester 30.76 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 28). This optimal management regime will generate the maximum SEV of -$222.29 (Table 36), with a NPW of -$219.59 per acre (Table 32). This financially optimal rotation would produce an estimated 2,863.44 cubic feet of pulpwood and 8.86 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 30.76 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 28). This optimal management regime will generate the maximum SEV of -$270.40 (Table 36), with a NPW of -$269.51 per acre (Table 32). This financially optimal rotation would produce an estimated 2,915.66 cubic feet of pulpwood and 8.21 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 30.69 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 59 (Table 28). This optimal management regime will generate the maximum SEV of -$297.18 (Table 36), with a NPW of -$296.92 per acre (Table 32). This financially optimal rotation would produce an estimated 2,915.66 cubic feet of pulpwood and 8.21 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 30.69 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 28). This optimal management regime will generate the maximum SEV of -$314.17 (Table 36), with a NPW of -$314.10 per acre (Table 32). This financially optimal rotation would produce an estimated 2,915.66 cubic feet of pulpwood and 8.21 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 30.69 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 28). This optimal management regime will generate the maximum SEV of $531.22 (Table 36), with a NPW of $332.42 per acre (Table 32). This financially optimal rotation would produce an estimated 2,767.13 cubic feet of pulpwood and 22.71 MBF of sawlogs

per acre from the thinning and final harvest (Table 40), and sequester 42.15 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 28). This optimal management regime will generate the maximum SEV of -$53.48 (Table 36), with a NPW of -$51.54 per acre (Table 32). This financially optimal rotation would produce an estimated 3,086.97 cubic feet of pulpwood and 14.19 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 37.61 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 33 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 28). This optimal management regime will generate the maximum SEV of -$194.44 (Table 36), with a NPW of -$191.29 per acre (Table 32). This financially optimal rotation would produce an estimated 3,427.93 cubic feet of pulpwood and 10.87 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 33.26 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 32 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 28). This optimal management regime will generate the maximum SEV of -$254.13 (Table 36), with a NPW of -$252.91 per acre (Table 32). This financially optimal rotation would produce an estimated 3,349.95 cubic feet of pulpwood and 9.99 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 32.50 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 28). This optimal management regime will generate the maximum SEV of -$285.98 (Table 36), with a NPW of -$285.19 per acre (Table 32). This financially optimal rotation would produce an estimated 3,412.90 cubic feet of pulpwood and 6.64 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 29.41 net tons of carbon per acre during one rotation (Table 24).

Red maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 28). This optimal management regime will generate the maximum SEV of -$305.80 (Table 36), with a NPW of -$305.52 per acre (Table 32). This financially optimal rotation would produce an estimated 3,412.90 cubic feet of pulpwood and 6.64 MBF of

sawlogs per acre from the thinning and final harvest (Table 40), and sequester 29.41 net tons of carbon per acre during one rotation (Table 24).

<u>Lake States-Red maple - Timber Only Rotations (C = $37/ton)</u>

Red maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 72 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of $1,144.02 (Table 37), with a NPW of $1,023.08 per acre (Table 33). This means that $1,144.02 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,023.08 per acre for managing one rotation, or $1,144.02 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,061.60 cubic feet of pulpwood and 14.88 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 41.60 net tons of carbon per acre during one rotation (Table 25). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 72 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of $379.18 (Table 37), with a NPW of $374.71 per acre (Table 33). This financially optimal rotation would produce an estimated 3,061.60 cubic feet of pulpwood and 14.88 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 41.60 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 67 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 29). This optimal management regime will generate the maximum SEV of $107.79 (Table 37), with a NPW of $107.59 per acre (Table 33). This financially optimal rotation would produce an estimated 2,685.33 cubic feet of pulpwood and 22.69 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 37.81 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 68 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 29). This optimal management regime will generate the maximum SEV of -$33.49 (Table 37), with a NPW of -$33.48 per acre (Table 33). This financially optimal rotation would produce an estimated 2,715.18 cubic feet of pulpwood and 13.89 MBF of sawlogs

per acre from the thinning and final harvest (Table 41), and sequester 38.06 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 68 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 29). This optimal management regime will generate the maximum SEV of -$119.04 (Table 37), with a NPW of -$119.03 per acre (Table 33). This financially optimal rotation would produce an estimated 2,715.83 cubic feet of pulpwood and 13.89 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 38.01 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 71 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$175.27 (Table 37), with a NPW of -$175.27 per acre (Table 33). This financially optimal rotation would produce an estimated 2,049.34 cubic feet of pulpwood and 13.75 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 33.16 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 43 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 73 (Table 29). This optimal management regime will generate the maximum SEV of $1,246.52 (Table 37), with a NPW of $1,046.01 per acre (Table 33). This financially optimal rotation would produce an estimated 3,011.77 cubic feet of pulpwood and 12.31 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 34.52 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 43 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 73 (Table 29). This optimal management regime will generate the maximum SEV of $454.45 (Table 37), with a NPW of $442.17 per acre (Table 33). This financially optimal rotation would produce an estimated 3,011.77 cubic feet of pulpwood and 12.31 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 34.52 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 43 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 29). This optimal management regime will generate the maximum SEV of $164.81 (Table 37), with a NPW of $164.18 per acre (Table 33). This financially optimal rotation would produce an estimated 2,642.56 cubic feet of pulpwood and 12.53 MBF of sawlogs per

acre from the thinning and final harvest (Table 41), and sequester 32.28 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 43 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 29). This optimal management regime will generate the maximum SEV of $11.02 (Table 37), with a NPW of $11.01 per acre (Table 33). This financially optimal rotation would produce an estimated 2,642.56 cubic feet of pulpwood and 12.53 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 32.28 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 50 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 29). This optimal management regime will generate the maximum SEV of -$83.63 (Table 37), with a NPW of -$83.62 per acre (Table 33). This financially optimal rotation would produce an estimated 2,745.22 cubic feet of pulpwood and 12.52 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 32.49 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 50 (with 20 percent of

basal area removed) and a final harvest is conducted at stand age 76 (Table 29). This optimal management regime will generate the maximum SEV of -$146.54 (Table 37), with a NPW of -$146.54 per acre (Table 33). This financially optimal rotation would produce an estimated 2,745.22 cubic feet of pulpwood and 12.52 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 32.49 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 29). This optimal management regime will generate the maximum SEV of $1,573.30 (Table 37), with a NPW of $1,355.08 per acre (Table 33). This financially optimal rotation would produce an estimated 2,767.13 cubic feet of pulpwood and 22.72 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 42.15 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 60 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 29). This optimal management regime will generate the maximum SEV of $560.63 (Table 37), with a NPW of $551.32 per acre (Table 33). This financially optimal rotation would produce an estimated 3,144.94 cubic feet of pulpwood and 22.87 MBF of sawlogs

per acre from the thinning and final harvest (Table 41), and sequester 44.39 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 58 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 73 (Table 29). This optimal management regime will generate the maximum SEV of $225.87 (Table 37), with a NPW of $224.80 per acre (Table 33). This financially optimal rotation would produce an estimated 3,292.60 cubic feet of pulpwood and 17.78 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 39.69 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 58 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 29). This optimal management regime will generate the maximum SEV of $55.18 (Table 37), with a NPW of $55.13 per acre (Table 33). This financially optimal rotation would produce an estimated 3,033.57 cubic feet of pulpwood and 17.83 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 38.06 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 58 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 29). This optimal management regime will generate the maximum SEV of -$49.11 (Table 37), with a NPW of -$49.11 per acre (Table 33). This financially optimal rotation would produce an estimated 3,033.57 cubic feet of pulpwood and 17.83 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 38.06 net tons of carbon per acre during one rotation (Table 25).

Red maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 66 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 29). This optimal management regime will generate the maximum SEV of -$118.70 (Table 37), with a NPW of -$118.70 per acre (Table 33). This financially optimal rotation would produce an estimated 2,696.67 cubic feet of pulpwood and 20.81 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 39.64 net tons of carbon per acre during one rotation (Table 25).

<u>Lake States- Red maple - Timber Only Rotations (C = $50/ton)</u>

Red maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 72 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $1,591.94 (Table 38), with a NPW of $1,432.65 per acre (Table 34). This means that $1,591.94 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,432.65 per acre for managing one rotation, or $1,591.94 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,061.60 cubic feet of pulpwood and 14.88 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 41.60 net tons of carbon per acre during one rotation (Table 26). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 72 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $635.55 (Table 38), with a NPW of $628.05 per acre (Table 34). This financially optimal rotation would produce an estimated 3,061.60 cubic feet of pulpwood and 14.88 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 41.60 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 67 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table

30). This optimal management regime will generate the maximum SEV of $278.24 (Table 38), with a NPW of $277.82 per acre (Table 34). This financially optimal rotation would produce an estimated 2,687.86 cubic feet of pulpwood and 13.90 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 38.04 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 68 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $87.95 (Table 38), with a NPW of $87.94 per acre (Table 34). This financially optimal rotation would produce an estimated 2,718.55 cubic feet of pulpwood and 14.03 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 38.27 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 71 (with 22 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$27.96 (Table 38), with a NPW of -$27.96 per acre (Table 34). This financially optimal rotation would produce an estimated 2,049.34 cubic feet of pulpwood and 13.75 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 33.16 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$104.34 (Table 38), with a NPW of -$104.34 per acre (Table 34). This financially optimal rotation would produce an estimated 1,723.88 cubic feet of pulpwood and 11.83 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 34.07 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 43 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 73 (Table 30). This optimal management regime will generate the maximum SEV of $1,715.12 (Table 38), with a NPW of $1,439.24 per acre (Table 34). This financially optimal rotation would produce an estimated 3,011.77 cubic feet of pulpwood and 12.31 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 34.52 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 43 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 30). This optimal management regime will generate the maximum SEV of $733.03 (Table 38), with a NPW of $723.02 per acre (Table 34). This financially optimal rotation would

produce an estimated 2,376.12 cubic feet of pulpwood and 16.49 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 35.71 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 43 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 30). This optimal management regime will generate the maximum SEV of $354.68 (Table 38), with a NPW of $354.15 per acre (Table 34). This financially optimal rotation would produce an estimated 2,083.10 cubic feet of pulpwood and 16.27 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 33.34 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 50 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 30). This optimal management regime will generate the maximum SEV of $147.86 (Table 38), with a NPW of $147.83 per acre (Table 34). This financially optimal rotation would produce an estimated 2,202.09 cubic feet of pulpwood and 16.18 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 33.67 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 68 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $19.84 (Table 38), with a NPW of $19.84 per acre (Table 34). This financially optimal rotation would produce an estimated 1,949.81 cubic feet of pulpwood and 18.75 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 35.58 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 68 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 30). This optimal management regime will generate the maximum SEV of -$65.52 (Table 38), with a NPW of -$65.52 per acre (Table 34). This financially optimal rotation would produce an estimated 1,852.02 cubic feet of pulpwood and 18.12 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 34.07 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 60 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 30). This optimal management regime will generate the maximum SEV of $2,087.96 (Table 38), with a NPW of $1,825.59 per acre (Table 34). This financially optimal

rotation would produce an estimated 3,145.12 cubic feet of pulpwood and 22.87 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 44.39 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 60 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 30). This optimal management regime will generate the maximum SEV of $865.29 (Table 38), with a NPW of $850.93 per acre (Table 34). This financially optimal rotation would produce an estimated 3,145.12 cubic feet of pulpwood and 22.87 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 44.39 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 58 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 30). This optimal management regime will generate the maximum SEV of $433.23 (Table 38), with a NPW of $431.32 per acre (Table 34). This financially optimal rotation would produce an estimated 3,033.57 cubic feet of pulpwood and 17.83 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 38.06 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 58 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 30). This optimal management regime will generate the maximum SEV of $206.52 (Table 38), with a NPW of $206.36 per acre (Table 34). This financially optimal rotation would produce an estimated 3,033.57 cubic feet of pulpwood and 17.83 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 38.06 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 67 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 30). This optimal management regime will generate the maximum SEV of $66.12 (Table 38), with a NPW of $66.11 per acre (Table 34). This financially optimal rotation would produce an estimated 2,838.08 cubic feet of pulpwood and 21.58 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 41.67 net tons of carbon per acre during one rotation (Table 26).

Red maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 67 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 30). This optimal management regime will generate the maximum SEV of -$27.94 (Table 38), with a NPW of -$27.94 per acre (Table 34). This financially optimal rotation

would produce an estimated 2,838.08 cubic feet of pulpwood and 21.58 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 41.67 net tons of carbon per acre during one rotation (Table 26).

Species Red maple Region South

Site indices 60, 70 and 80 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 9-in. inside bark top diameter for trees with a minimum of 12 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 11-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 20 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 25, 30 and 35% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.245225694 and 0.434027778, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Philips (1977) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$\text{Log}_{10}Y = -0.92222 + 1.00528 \log_{10} (D^2TH)$$

where:

Y = dry weight (lb.)

D = diameter at breast height (in.)

TH = total height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 1.6% and 1.24% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be \$196/mbf (Scribner) (Timber Mart South, Inc. 2000-2005) and pulpwood price was assumed to be \$16.44/cord (Timber Mart South, Inc. 2000-2005). The price of carbon was assumed to be \$0, \$10, \$37 or \$50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of red maple plantations in the South.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$60.00	Only once	Year 0	
Seedlings[b] (436 seedlings/ac)	$152.60	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).

[b]Data from Hans M. Williams, personal communication, Stephen F. Austin State University, December 19, 2006.

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Table 45. Total tons of carbon sequestered per acre for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	42.54	42.83	42.91	42.91	42.91	39.74
70	46.46	46.46	49.86	49.86	44.34	44.34
80	55.29	55.29	55.29	48.93	49.13	48.48

[1]Base age 50.

Table 46. Total tons of carbon sequestered per acre for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	46.00	56.00	56.00	56.00	57.26	60.60
70	49.80	61.12	61.12	61.33	61.33	61.33
80	63.03	63.03	62.47	62.75	62.60	62.60

[1]Base age 50.

Table 47. Total tons of carbon sequestered per acre for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	60.60	60.60	60.60	60.60	60.60	60.60
70	61.12	61.12	59.62	59.62	58.69	58.64
80	62.15	61.66	61.27	57.30	57.30	57.30

[1]Base age 50.

Table 48. Total tons of carbon sequestered per acre for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	60.60	60.60	60.60	60.60	60.60	60.60
70	61.12	61.12	59.62	58.69	58.69	58.69
80	62.15	61.27	57.30	57.30	56.89	56.89

[1]Base age 50.

Table 49. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<58-73-**80**[2]> (35%)[3]	<58-66-**80**>[4](35%)	<58-64-**80**> (35%)	<58-64-**80**> (35%)	<58-64-**80**> (35%)	<57-62-**79**> (35%)
70	52-60-**80** (35%)	<52-60-**80**> (35%)	<53-60-**79**> (35%)	<53-60-**79**> (35%)	<51-56-**80**> (35%)	<51-56-**80**> (35%)
80	50-60-**80** (35%)	<50-60-**80**> (35%)	<50-60-**80**> (35%)	<47-52-**79**> (35%)	<47-52-**76**> (35%)	<46-51-**70**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 50. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	59-69-**80**[2] (35%)[3]	<65-74-**80>**[4](35%)	<65-74-**80>** (35%)	<65-74-**80>** (35%)	<68-**80>** (25%)	<75-**80>** (25%)
70	53-60-**80** (35%)	<62-72-**80>** (35%)	<62-72-**80>** (35%)	<62-67-**80>** (35%)	<62-67-**80>** (35%)	<62-67-**80>** (35%)
80	55-62-**80** (35%)	<55-62-**80>** (35%)	<60-65-**80>** (35%)	<58-67-**77>** (35%)	<60-68-**76>** (35%)	<60-68-**76>** (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 51. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	75-**80**[2] (25%)[3]	75-**80** (25%)	<75-**80**>[4] (25%)	<75-**80**> (25%)	<75-**80**> (25%)	<75-**80**> (25%)
70	62-72-**80** (35%)	62-72-**80** (35%)	<73-**80**> (35%)	<73-**80**> (35%)	<75-**80**> (30%)	<75-**80**> (25%)
80	57-73-**80** (30%)	63-69-**80**> (25%)	65-74-**80** (25%)	<74-**80**> (30%)	<74-**80**> (30%)	<74-**80**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 52. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	75-**80**[2] (25%)[3]	75-**80** (25%)	<75-**80**>[4] (25%)	<75-**80**> (25%)	<75-**80**> (25%)	<75-**80**> (25%)
70	62-72-**80** (35%)	62-72-**80** (35%)	73-**80** (35%)	<75-**80**> (30%)	<75-**80**> (30%)	<75-**80**> (30%)
80	57-73-**80** (30%)	65-74-**80**> (25%)	74-**80** (30%)	<74-**80**> (30%)	<75-**80**> (25%)	<75-**80**> (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 53. Net present worth of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
Site Index[1]	-$195.01					
60	-$128.05	-$363.60	-$396.89	-$400.49	-$399.85	-$398.87
70	$420.11	-$279.98	-$382.75	-$397.83	-$399.28	-$398.73
80	$503.41	-$263.90	-$379.41	-$396.72	-$398.85	-$398.56

[1]Base age 50.

Table 54. Net present worth of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$97.36	-$257.06	-$343.63	-$370.53	-$381.11	-$386.19
70	$694.04	-$138.07	-$305.86	-$352.55	-$370.02	-$378.38
80	$874.47	-$71.12	-$274.47	-$333.94	-$357.48	-$369.15

[1]Base age 50.

Table 55. Net present worth of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$821.47	$65.05	-$190.55	-$287.14	-$329.81	-$351.75
70	$1,554.05	$288.40	-$86.97	-$226.51	-$289.79	-$323.04
80	$1,898.44	$476.79	$21.50	-$159.48	-$243.93	-$289.00

[1]Base age 50.

Table 56. Net present worth of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$1,194.19	$222.92	-$116.51	-$246.95	-$305.11	-$335.16
70	$1,984.82	$493.74	$21.14	-$165.35	-$251.08	-$296.37
80	$2,408.69	$746.98	$165.89	-$75.05	-$189.16	-$250.39

[1]Base age 50.

Table 57. Soil expectation value of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$148.09	-$370.72	-$398.02	-$400.66	-$399.88	-$398.88
70	$485.85	-$285.46	-$383.93	-$398.03	-$399.31	-$398.73
80	$582.19	-$269.07	-$380.50	-$396.91	-$398.89	-$398.57

[1]Base age 50.

Table 58. Soil expectation value of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$112.60	-$262.09	-$344.61	-$370.69	-$381.13	-$386.19
70	$802.66	-$140.78	-$306.74	-$352.71	-$370.05	-$378.39
80	$1,011.32	-$72.52	-$275.26	-$334.14	-$357.53	-$369.16

[1]Base age 50.

Table 59. Soil expectation value of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$950.02	$66.33	-$191.09	-$287.27	-$329.83	-$351.75
70	$1,797.26	$294.05	-$87.22	-$226.61	-$289.81	-$323.04
80	$2,195.54	$486.13	$21.56	-$159.55	-$243.95	-$289.00

[1]Base age 50.

Table 60. Soil expectation value of the financially optimal thinning and final harvest schedules for red maple plantations by site index and real alternative rates of return in the southern states region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$1,381.08	$227.28	-$116.85	-$247.06	-$305.13	-$335.17
70	$2,295.44	$503.41	$21.20	-$165.42	-$251.10	-$296.37
80	$2,785.65	$761.61	$166.37	-$75.08	-$189.17	-$250.39

[1]Base age 50.

Table 61. Volume removed from the financially optimal schedules for red maple plantations by soil productivity and real alternative rates of return in the southern states region). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	58-73-**80**[3] (35%)[4]	623.63	0	895.38	0	1,748.20	2.11	3,267.21	2.11
	5.0%	58-66-**80** (35%)	623.63	0	706.83	0	1,759.40	2.14	3,089.86	2.14
	7.5%	58-64-**80** (35%)	623.63	0	650.83	0	1,760.26	2.13	3,034.72	2.13
	10.0%	58-66-**80** (35%)	623.63	0	650.83	0	1,760.26	2.13	3,034.72	2.13
	12.5%	58-66-**80** (35%)	623.63	0	650.83	0	1,760.26	2.13	3,034.72	2.13
	15.0%	57-62-**79** (35%)	574.68	0	596.68	0	1,860.96	1.36	3,032.32	1.36
70	2.5%	52-60-**80** (35%)	633.87	0	751.56	0	1,307.93	7.52	2,693.36	7.52
	5.0%	52-60-**80** (35%)	633.87	0	751.56	0	1,307.93	7.52	2,693.36	7.52
	7.5%	53-60-**79** (35%)	716.07	0	747.60	0	1,298.57	7.12	2,762.24	7.12
	10.0%	53-60-**79** (35%)	716.07	0	747.60	0	1,298.57	7.12	2,762.24	7.12
	12.5%	51-56-**80** (35%)	580.76	0	642.52	0	1,353.01	7.35	2,576.29	7.35
	15.0%	51-56-**80** (35%)	580.76	0	642.52	0	1,353.01	7.35	2,576.29	7.35
80	2.5%	50-60-**80** (35%)	868.37	0	955.14	0	1,172.82	10.87	2,996.33	10.87
	5.0%	50-60-**80** (35%)	868.37	0	955.14	0	1,172.82	10.87	2,996.33	10.87
	7.5%	50-60-**80** (35%)	868.37	0	955.14	0	1,172.82	10.87	2,996.33	10.87
	10.0%	47-52-**79** (35%)	618.36	0	699.72	0	1,311.13	10.18	2,629.21	10.18
	12.5%	47-52-**76** (35%)	618.36	0	699.72	0	1,552.53	7.80	2,870.61	7.80
	15.0%	46-51-**70** (35%)	559.70	0	672.39	0	2,050.12	3.14	3,282.21	3.14

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 62. Volume removed from the financially optimal schedules for red maple plantations by soil productivity and real alternative rates of return in the southern states region. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	59-69-**80**[3] (35%)[4]	673.90	0	785.38	0	1,751.99	2.09	3,211.27	2.09
	5.0%	65-74-**80** (35%)	945.66	0	910.15	0	1,827.28	1.34	3,683.09	1.34
	7.5%	65-74-**80** (35%)	945.66	0	910.15	0	1,827.28	1.34	3,683.09	1.34
	10.0%	65-74-**80** (35%)	945.66	0	910.15	0	1,827.28	1.34	3,683.09	1.34
	12.5%	68-**80** (25%)	737.72	0	-[5]	-	3,421.71	0.68	4,159.43	0.68
	15.0%	75-**80** (25%)	922.97	0	-	-	3,489.46	0	4,412.43	0
70	2.5%	53-60-**80** (35%)	716.07	0	747.60	0	2,776.91	7.41	4,240.58	7.41
	5.0%	62-72-**80** (35%)	1,140.00	0	1,114.67	0	1,436.66	6.14	3,691.33	6.14
	7.5%	62-72-**80** (35%)	1,140.00	0	1,114.67	0	1,436.66	6.14	3,691.33	6.14
	10.0%	62-67-**80** (35%)	1,140.00	0	949.58	0	1,461.46	6.19	3,551.04	6.19
	12.5%	62-67-**80** (35%)	1,140.00	0	949.58	0	1,461.46	6.19	3,551.04	6.19
	15.0%	62-67-**80** (35%)	1,140.00	0	949.58	0	1,461.46	6.19	3,551.04	6.19
80	2.5%	55-62-**80** (35%)	1,112.20	0	1,011.32	0	1,175.41	10.61	3,298.93	10.61
	5.0%	55-62-**80** (35%)	1,112.20	0	1,011.32	0	1,175.41	10.61	3,298.93	10.61
	7.5%	60-65-**80** (35%)	1,331.89	0	1,108.17	0	1,279.18	9.73	3,719.24	9.73
	10.0%	58-67-**77** (35%)	1,244.21	0	1,190.72	0	1,366.11	8.15	3,801.04	8.15
	12.5%	60-68-**76** (35%)	1,331.89	0	1,220.44	0	1,470.23	7.14	4,022.56	7.14
	15.0%	60-68-**76** (35%)	1,331.89	0	1,220.44	0	1,470.23	7.14	4,022.56	7.14

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 63. Volume removed from the financially optimal schedules for red maple plantations by soil productivity and real alternative rates of return in the southern states region. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	75-**80**[3] (25%)[4]	922.97	0	-[5]	-	3,489.46	0	4,412.43	0
	5.0%	75-**80** (25%)	922.97	0	-	-	3,489.46	0	4,412.43	0
	7.5%	75-**80** (25%)	922.97	0	-	-	3,489.46	0	4,412.43	0
	10.0%	75-**80** (25%)	922.97	0	-	-	3,489.46	0	4,412.43	0
	12.5%	75-**80** (25%)	922.97	0	-	-	3,489.46	0	4,412.43	0
	15.0%	75-**80** (25%)	922.97	0	-	-	3,489.46	0	4,412.43	0
70	2.5%	62-72-**80** (35%)	1,140.00	0	1,114.67	0	1,436.66	6.14	3,691.33	6.14
	5.0%	62-72-**80** (35%)	1,140.00	0	1,114.67	0	1,436.66	6.14	3,691.33	6.14
	7.5%	73-**80** (35%)	1,585.00	0	-	-	3,064.00	3.72	4,649.00	3.72
	10.0%	73-**80** (35%)	1,585.00	0	-	-	3,064.00	3.72	4,649.00	3.72
	12.5%	75-**80** (30%)	1,408.53	0	-	-	3,432.49	3.04	4,841.02	3.04
	15.0%	75-**80** (25%)	1,163.10	0	-	-	3,861.46	2.29	5,024.56	2.29
80	2.5%	57-73-**80** (30%)	1,018.03	0	1,300.06	0	1,727.34	9.56	4,045.43	9.56
	5.0%	63-69-**80** (25%)	1,038.42	0	1,005.29	0	2,393.36	8.60	4,437.07	8.60
	7.5%	65-74-**80** (25%)	1,104.66	0	1,148.81	0	2,531.01	7.75	4,784.48	7.75
	10.0%	74-**80** (30%)	1,650.27	0	-	-	3,521.56	6.00	5,171.83	6.00
	12.5%	74-**80** (30%)	1,650.27	0	-	-	3,521.56	6.00	5,171.83	6.00
	15.0%	74-**80** (30%)	1,650.27	0	-	-	3,521.56	6.00	5,171.83	6.00

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 64. Volume removed from the financially optimal schedules for red maple plantations by soil productivity and real alternative rates of return in the southern states region. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	75-**80**[3] (25%)[4]	922.97	0	-[5]	-	3,489.46	0	4,412.43	0
	5.0%	75-**80** (25%)	922.97	0	-	-	3,489.46	0	4,412.43	0
	7.5%	75-**80** (25%)	922.97	0	-	-	3,489.46	0	4,412.43	0
	10.0%	75-**80** (25%)	922.97	0	-	-	3,489.46	0	4,412.43	0
	12.5%	75-**80** (25%)	922.97	0	-	-	3,489.46	0	4,412.43	0
	15.0%	75-**80** (25%)	922.97	0	-	-	3,489.46	0	4,412.43	0
70	2.5%	62-72-**80** (35%)	1,140.00	0	1,114.67	0	1,436.66	6.14	3,691.33	6.14
	5.0%	62-72-**80** (35%)	1,140.00	0	1,114.67	0	1,436.66	6.14	3,691.33	6.14
	7.5%	73-**80** (35%)	1,585.00	0	-	-	3,064.00	3.72	4,649.00	3.72
	10.0%	75-**80** (30%)	1,408.53	0	-	-	3,432.49	3.04	4,841.02	3.04
	12.5%	75-**80** (30%)	1,408.53	0	-	-	3,432.49	3.04	4,841.02	3.04
	15.0%	75-**80** (30%)	1,408.53	0	-	-	3,432.49	3.04	4,841.02	3.04
80	2.5%	57-73-**80** (30%)	1,018.03	0	1,300.06	0	1,727.34	9.56	4,045.43	9.56
	5.0%	65-74-**80** (25%)	1,104.66	0	1,148.81	0	2,531.01	7.75	4,784.48	7.75
	7.5%	74-**80** (30%)	1,650.27	0	-	-	3,521.56	6.00	5,171.83	6.00
	10.0%	74-**80** (30%)	1,650.27	0	-	-	3,521.56	6.00	5,171.83	6.00
	12.5%	75-**80** (25%)	1,390.55	0	-	-	3,990.71	5.20	5,381.26	5.20
	15.0%	75-**80** (25%)	1,390.55	0	-	-	3,990.71	5.20	5,381.26	5.20

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 65. Financially optimal thinning and final harvest schedules for red maple plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	60	<58-73-**80**[2]>[3] (35%)[4]	59-69-**80** (35%)	0%	75-**80** (25%)	0%	75-**80** (25%)	0%
	70	52-60-**80** (35%)	53-60-**80** (35%)	0%	62-72-**80** (35%)	0%	62-72-**80** (35%)	0%
	80	50-60-**80** (35%)	55-62-**80** (35%)	0%	57-73-**80** (30%)	0%	57-73-**80** (30%)	0%
5.00%	60	<58-66-**80**> (35%)	<65-74-**80**> (35%)	0%	75-**80** (25%)	0%	75-**80** (25%)	0%
	70	<52-60-**80**> (35%)	<62-72-**80**> (35%)	0%	62-72-**80** (35%)	0%	62-72-**80** (35%)	0%
	80	<50-60-**80**> (35%)	<55-62-**80**> (35%)	0%	63-69-**80** (25%)	0%	65-74-**80**> (25%)	0%
7.50%	60	<58-64-**80**> (35%)	<65-74-**80**> (35%)	0%	<75-**80**> (25%)	0%	<75-**80**> (25%)	0%
	70	<53-60-**79**> (35%)	<62-72-**80**> (35%)	1%	<73-**80**> (35%)	1%	73-**80** (35%)	1%
	80	<50-60-**80**> (35%)	<60-65-**80**> (35%)	0%	65-74-**80** (25%)	0%	74-**80** (30%)	0%
10.00%	60	<58-64-**80**> (35%)	<65-74-**80**> (35%)	0%	<75-**80**> (25%)	0%	<75-**80**> (25%)	0%
	70	<53-60-**79**> (35%)	<62-67-**80**> (35%)	1%	<73-**80**> (35%)	1%	<75-**80**> (30%)	1%
	80	<47-52-**79**> (35%)	<58-67-**77**> (35%)	-3%	<74-**80**> (30%)	1%	<74-**80**> (30%)	1%
12.50%	60	<58-64-**80**> (35%)	<68-**80**> (25%)	0%	<75-**80**> (25%)	0%	<75-**80**> (25%)	0%
	70	<51-56-**80**> (35%)	<62-67-**80**> (35%)	0%	<75-**80**> (30%)	0%	<75-**80**> (30%)	0%
	80	<47-52-**76**> (35%)	<60-68-**76**> (35%)	0%	<74-**80**> (30%)	5%	<75-**80**> (25%)	5%
15.00%	60	<57-62-**79**> (35%)	<75-**80**> (25%)	1%	<75-**80**> (25%)	1%	<75-**80**> (25%)	1%
	70	<51-56-**80**> (35%)	<62-67-**80**> (35%)	0%	<75-**80**> (25%)	0%	<75-**80**> (30%)	0%
	80	<46-51-**70**> (35%)	<60-68-**76**> (35%)	9%	<74-**80**> (30%)	14%	<75-**80**> (25%)	14%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

[4]Number in parentheses indicates the percentage of basal area removed during thinning

Table 66. The soil expectation value ($/acre) of the financially optimal rotations for red maple plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	60	-148.09	112.60		685.77		993.22	
	70	485.85	802.66	65%	891.15	270%	1,235.50	372%
	80	582.19	1,011.32	74%	1,172.39	277%	1,541.93	378%
5.00%	60	-370.72	-262.09		66.69		216.56	
	70	-285.46	-140.78		152.26		323.69	
	80	-269.07	-72.52		249.00		442.05	
7.50%	60	-398.02	-344.61		-134.46		-44.09	
	70	-383.93	-306.74		-84.80		21.06	
	80	-380.50	-275.26		-32.70		89.42	
10.00%	60	-400.66	-370.69		-227.54		-167.57	
	70	-398.03	-352.71		-194.10		-122.77	
	80	-396.91	-334.14		-159.81		-76.90	
12.50%	60	-399.88	-381.13		-277.93		-235.38	
	70	-399.31	-370.05		-253.39		-202.28	
	80	-398.89	-357.53		-228.33		-168.56	
15.00%	60	-398.88	-386.19		-308.09		-276.29	
	70	-398.73	-378.39		-289.04		-250.56	
	80	-398.57	-369.16		-269.55		-224.27	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>Southern - Red maple - Timber Only Rotations (C = $0/ton)</u>

Red maple, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 73 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 49). This optimal management regime will generate the maximum SEV of -$148.09 (Table 57), with a NPW of -$128.05 per acre (Table 53). This means that -$148.09 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$128.05 per acre for managing one rotation, or -$148.09 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,267.21 cubic feet of pulpwood and 2.11 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 42.54 net tons of carbon per acre during one rotation (Table 45). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red maple, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 66 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 49). This optimal management regime will generate the maximum SEV of -$370.72 (Table 57), with a NPW of -$363.60 per acre (Table 53). This financially optimal

rotation would produce an estimated 3,089.33 cubic feet of pulpwood and 2.14 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 42.83 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 64 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 49). This optimal management regime will generate the maximum SEV of -$398.02 (Table 57), with a NPW of -$396.89 per acre (Table 53). This financially optimal rotation would produce an estimated 3,034.72 cubic feet of pulpwood and 2.13 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 42.91 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 64 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 49). This optimal management regime will generate the maximum SEV of -$400.66 (Table 57), with a NPW of -$400.49 per acre (Table 53). This financially optimal rotation would produce an estimated 3,034.72 cubic feet of pulpwood and 2.13 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 42.91 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 64 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 49). This optimal management regime will generate the maximum SEV of -$399.88 (Table 57), with a NPW of -$399.85 per acre (Table 53). This financially optimal rotation would produce an estimated 3,034.72 cubic feet of pulpwood and 2.13 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 42.91 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 62 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 49). This optimal management regime will generate the maximum SEV of -$398.88 (Table 57), with a NPW of -$398.87 per acre (Table 53). This financially optimal rotation would produce an estimated 3,032.32 cubic feet of pulpwood and 1.36 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 39.74 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 60 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 49). This optimal management regime will generate the maximum SEV of $485.85 (Table 57), with a NPW of $420.11 per acre (Table 53). This financially optimal rotation

would produce an estimated 2,693.36 cubic feet of pulpwood and 7.52 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 46.46 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 60 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 49). This optimal management regime will generate the maximum SEV of -$285.46 (Table 57), with a NPW of -$279.98 per acre (Table 53). This financially optimal rotation would produce an estimated 2,693.36 cubic feet of pulpwood and 7.52 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 46.46 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 53 and 60 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 49). This optimal management regime will generate the maximum SEV of -$383.93 (Table 57), with a NPW of -$382.75 per acre (Table 53). This financially optimal rotation would produce an estimated 2,762.24 cubic feet of pulpwood and 7.12 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 49.86 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 53 and 60 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 49). This optimal management regime will generate the maximum SEV of -$398.03 (Table 57), with a NPW of -$397.83 per acre (Table 53). This financially optimal rotation would produce an estimated 2,762.24 cubic feet of pulpwood and 7.12 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 49.86 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 56 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 49). This optimal management regime will generate the maximum SEV of -$399.31 (Table 57), with a NPW of -$399.28 per acre (Table 53). This financially optimal rotation would produce an estimated 2,576.29 cubic feet of pulpwood and 7.35 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 44.34 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 56 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 49). This optimal management regime will generate the maximum SEV of -$398.73 (Table 57), with a NPW of -$398.73 per acre (Table 53). This financially optimal

rotation would produce an estimated 2,576.29 cubic feet of pulpwood and 7.35 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 44.34 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 60 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 49). This optimal management regime will generate the maximum SEV of $582.19 (Table 57), with a NPW of $503.41 per acre (Table 53). This financially optimal rotation would produce an estimated 2,996.33 cubic feet of pulpwood and 10.87 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 55.29 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 60 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 49). This optimal management regime will generate the maximum SEV of -$269.07 (Table 57), with a NPW of -$263.90 per acre (Table 53). This financially optimal rotation would produce an estimated 2,996.33 cubic feet of pulpwood and 10.87 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 55.29 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 60 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 49). This optimal management regime will generate the maximum SEV of -$380.50 (Table 57), with a NPW of -$379.41 per acre (Table 53). This financially optimal rotation would produce an estimated 2,996.33 cubic feet of pulpwood and 10.87 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 55.29 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 52 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 49). This optimal management regime will generate the maximum SEV of -$396.91 (Table 57), with a NPW of -$396.72 per acre (Table 53). This financially optimal rotation would produce an estimated 2,629.21 cubic feet of pulpwood and 10.18 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 48.93 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 52 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 49). This optimal management regime will generate the maximum SEV of -$398.89 (Table 57), with a NPW of -$398.85 per acre (Table 53). This financially optimal

rotation would produce an estimated 2,870.61 cubic feet of pulpwood and 7.80 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 49.13 net tons of carbon per acre during one rotation (Table 45).

Red maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 51 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 70 (Table 49). This optimal management regime will generate the maximum SEV of -$398.57 (Table 57), with a NPW of -$398.56 per acre (Table 53). This financially optimal rotation would produce an estimated 3,282.21 cubic feet of pulpwood and 3.14 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 48.48 net tons of carbon per acre during one rotation (Table 45).

<u>Southern- Red maple - Timber Only Rotations (C = $10/ton)</u>

Red maple, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 59 and 69 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of $112.60 (Table 58), with a NPW of $97.36 per acre (Table 54). This means that $112.60 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on

every dollar invested plus $97.36 per acre for managing one rotation, or $112.60 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,211.27 cubic feet of pulpwood and 2.09 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 46.00 net tons of carbon per acre during one rotation (Table 46). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red maple, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 65 and 74 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of -$262.09 (Table 58), with a NPW of -$257.06 per acre (Table 54). This financially optimal rotation would produce an estimated 3,683.09 cubic feet of pulpwood and 1.34 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 56.00 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 65 and 74 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of -$344.61 (Table 58), with a NPW of -$343.63 per acre (Table 54). This financially optimal rotation would produce an estimated 3,683.09 cubic feet of pulpwood and 1.34 MBF of

sawlogs per acre from the thinning and final harvest (Table 62), and sequester 56.00 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 65 and 74 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of -$370.69 (Table 58), with a NPW of -$370.53 per acre (Table 54). This financially optimal rotation would produce an estimated 3,683.09 cubic feet of pulpwood and 1.34 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 56.00 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 68 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of -$381.13 (Table 58), with a NPW of -$381.11 per acre (Table 54). This financially optimal rotation would produce an estimated 4,159.43 cubic feet of pulpwood and 0.68 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 57.26 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of

basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of -$386.19 (Table 58), with a NPW of -$386.19 per acre (Table 54). This financially optimal rotation would produce an estimated 4,412.43 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 60.60 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 53 and 60 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of $802.66 (Table 58), with a NPW of $694.04 per acre (Table 54). This financially optimal rotation would produce an estimated 4,240.58 cubic feet of pulpwood and 7.41 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 49.80 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 62 and 72 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of -$140.78 (Table 58), with a NPW of -$138.07 per acre (Table 54). This financially optimal rotation would produce an estimated 3,691.33 cubic feet of pulpwood and 6.14 MBF of

sawlogs per acre from the thinning and final harvest (Table 62), and sequester 61.12 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 62 and 72 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of -$306.74 (Table 58), with a NPW of -$305.86 per acre (Table 54). This financially optimal rotation would produce an estimated 3,691.33 cubic feet of pulpwood and 6.14 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 61.12 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 62 and 67 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of -$352.71 (Table 58), with a NPW of -$352.55 per acre (Table 54). This financially optimal rotation would produce an estimated 3,551.04 cubic feet of pulpwood and 6.19 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 61.33 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 62 and 67 (with 35

percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of -$370.05 (Table 58), with a NPW of -$370.02er acre (Table 54). This financially optimal rotation would produce an estimated 3,551.04 cubic feet of pulpwood and 6.19 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 61.33 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 62 and 67 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of -$378.39 (Table 58), with a NPW of -$378.38 per acre (Table 54). This financially optimal rotation would produce an estimated 3,551.04 cubic feet of pulpwood and 6.19 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 61.33 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 55 and 62 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of $1,011.32 (Table 58), with a NPW of $874.47 per acre (Table 54). This financially optimal rotation would produce an estimated 3,298.93 cubic feet of pulpwood and 10.61 MBF of sawlogs

per acre from the thinning and final harvest (Table 62), and sequester 63.03 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 55 and 62 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of -$72.52 (Table 58), with a NPW of -$71.12 per acre (Table 54). This financially optimal rotation would produce an estimated 3,298.93 cubic feet of pulpwood and 10.61 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 63.03 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 65 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 50). This optimal management regime will generate the maximum SEV of -$275.26 (Table 58), with a NPW of -$274.47 per acre (Table 54). This financially optimal rotation would produce an estimated 3,719.24 cubic feet of pulpwood and 9.73 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 62.47 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 67 (with 35

percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 50). This optimal management regime will generate the maximum SEV of -$334.14 (Table 58), with a NPW of -$333.94 per acre (Table 54). This financially optimal rotation would produce an estimated 3,801.04 cubic feet of pulpwood and 8.15 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 62.75 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 68 (with 76 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 50). This optimal management regime will generate the maximum SEV of -$357.53 (Table 58), with a NPW of -$357.48 per acre (Table 54). This financially optimal rotation would produce an estimated 4,022.56 cubic feet of pulpwood and 7.14 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 62.60 net tons of carbon per acre during one rotation (Table 46).

Red maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 68 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 50). This optimal management regime will generate the maximum SEV of -$369.16 (Table 58), with a NPW of -$369.15 per acre (Table 54). This financially optimal rotation would produce an estimated 4,022.56 cubic feet of pulpwood and 7.14 MBF of

sawlogs per acre from the thinning and final harvest (Table 62), and sequester 62.60 net tons of carbon per acre during one rotation (Table 46).

<u>Southern-Red maple - Timber Only Rotations (C = $37/ton)</u>

Red maple, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of $950.02 (Table 59), with a NPW of $821.47 per acre (Table 55). This means that $950.02 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $821.47 per acre for managing one rotation, or $950.02 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 4,412.43 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 60.60 net tons of carbon per acre during one rotation (Table 47). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red maple, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of

basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of $66.33 (Table 59), with a NPW of $65.05 per acre (Table 55). This financially optimal rotation would produce an estimated 4,412.43 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 60.60 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of -$191.09 (Table 59), with a NPW of -$190.55 per acre (Table 55). This financially optimal rotation would produce an estimated 4,412.43 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 60.60 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of -$287.27 (Table 59), with a NPW of -$287.14 per acre (Table 55). This financially optimal rotation would produce an estimated 4,412.43 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre

from the thinning and final harvest (Table 63), and sequester 60.60 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of -$329.83 (Table 59), with a NPW of -$329.81 per acre (Table 55). This financially optimal rotation would produce an estimated 4,412.43 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 60.60 net tons of carbon per acre during one rotation (Table 47)

Red maple, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of -$351.75 (Table 59), with a NPW of -$351.75 per acre (Table 55). This financially optimal rotation would produce an estimated 4,412.43 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 60.60 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 62 and 72 (with 35

percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of $1,797.26 (Table 59), with a NPW of $1,554.05 per acre (Table 55). This financially optimal rotation would produce an estimated 3,691.33 cubic feet of pulpwood and 6.14 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 61.12 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 62 and 72 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of $294.05 (Table 59), with a NPW of $288.40 per acre (Table 55). This financially optimal rotation would produce an estimated 3,691.33 cubic feet of pulpwood and 6.14 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 61.12 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of -$87.22 (Table 59), with a NPW of -$86.97 per acre (Table 55). This financially optimal rotation would produce an estimated 4,649.00 cubic feet of pulpwood and 3.72 MBF of sawlogs per acre from the

thinning and final harvest (Table 63), and sequester 59.62 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of -$226.61 (Table 59), with a NPW of -$226.51 per acre (Table 55). This financially optimal rotation would produce an estimated 4,649.00 cubic feet of pulpwood and 3.72 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 59.62 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of -$289.81 (Table 59), with a NPW of -$289.79 per acre (Table 55). This financially optimal rotation would produce an estimated 4,841.02 cubic feet of pulpwood and 3.04 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 58.69 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of

basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of -$323.04 (Table 59), with a NPW of -$323.04 per acre (Table 55). This financially optimal rotation would produce an estimated 5,024.56 cubic feet of pulpwood and 2.29 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 58.64 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 73 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of $2,195.54 (Table 59), with a NPW of $1,898.44 per acre (Table 55). This financially optimal rotation would produce an estimated 4,045.43 cubic feet of pulpwood and 9.56 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 62.15 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 63 and 69 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of $486.13 (Table 59), with a NPW of $476.79 per acre (Table 55). This financially optimal rotation would produce an estimated 4,437.07 cubic feet of pulpwood and 8.60 MBF of sawlogs

per acre from the thinning and final harvest (Table 63), and sequester 61.66 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 65 and 74 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of $21.56 (Table 59), with a NPW of $21.50 per acre (Table 55). This financially optimal rotation would produce an estimated 4,784.48 cubic feet of pulpwood and 7.75 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 61.27 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 74 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of -$159.55 (Table 59), with a NPW of -$159.48 per acre (Table 55). This financially optimal rotation would produce an estimated 5,171.83 cubic feet of pulpwood and 6.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 57.30 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 74 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of -$243.95 (Table 59), with a NPW of -$243.93 per acre (Table 55). This financially optimal rotation would produce an estimated 5,171.83 cubic feet of pulpwood and 6.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 57.30 net tons of carbon per acre during one rotation (Table 47).

Red maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 74 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 51). This optimal management regime will generate the maximum SEV of -$289.00 (Table 59), with a NPW of -$289.00 per acre (Table 55). This financially optimal rotation would produce an estimated 5,171.83 cubic feet of pulpwood and 6.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 57.30 net tons of carbon per acre during one rotation (Table 47).

Southern- Red maple - Timber Only Rotations (C = $50/ton)

Red maple, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of $1,381.08 (Table 60), with a NPW of $1,194.19 per acre (Table 56). This means that $1,381.08 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,194.19 per acre for managing one rotation, or $1,381.08 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 4,412.43 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 60.60 net tons of carbon per acre during one rotation (Table 48). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red maple, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of $227.28 (Table 60), with a NPW of $222.92 per acre (Table 56). This financially optimal rotation would produce an estimated 4,412.43 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 60.60 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This

optimal management regime will generate the maximum SEV of -$116.85 (Table 60), with a NPW of -$116.51 per acre (Table 56). This financially optimal rotation would produce an estimated 4,412.43 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 60.60 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of -$247.06 (Table 60), with a NPW of -$246.95 per acre (Table 56). This financially optimal rotation would produce an estimated 4,412.43 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 60.60 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of -$305.13 (Table 60), with a NPW of -$305.11 per acre (Table 56). This financially optimal rotation would produce an estimated 4,412.43 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 60.60 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of -$335.17 (Table 60), with a NPW of -$335.16 per acre (Table 56). This financially optimal rotation would produce an estimated 4,412.43 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 60.60 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 62 and 72 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of $2,295.44 (Table 60), with a NPW of $1,984.82 per acre (Table 56). This financially optimal rotation would produce an estimated 3,619.33 cubic feet of pulpwood and 6.14 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 61.12 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 62 and 72 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of $503.41

(Table 60), with a NPW of $493.74 per acre (Table 56). This financially optimal rotation would produce an estimated 3,619.33 cubic feet of pulpwood and 6.14 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 61.12 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of $21.20 (Table 60), with a NPW of $21.14 per acre (Table 56). This financially optimal rotation would produce an estimated 4,649.00 cubic feet of pulpwood and 3.72 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 59.62 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of -$165.42 (Table 60), with a NPW of -$165.35 per acre (Table 56). This financially optimal rotation would produce an estimated 4,841.02 cubic feet of pulpwood and 3.04 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 58.69 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of -$251.10 (Table 60), with a NPW of -$251.08 per acre (Table 56). This financially optimal rotation would produce an estimated 4,841.02 cubic feet of pulpwood and 3.04 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 58.69 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of -$296.37 (Table 60), with a NPW of -$296.37 per acre (Table 56). This financially optimal rotation would produce an estimated 4,841.02 cubic feet of pulpwood and 3.04 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 58.69 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 73 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of $2,785.65 (Table 60), with a NPW of $2,408.69 per acre (Table 56). This financially optimal

rotation would produce an estimated 4,045.43 cubic feet of pulpwood and 9.56 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 62.15 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 65 and 74 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of $761.61 (Table 60), with a NPW of $746.98 per acre (Table 56). This financially optimal rotation would produce an estimated 4,784.48 cubic feet of pulpwood and 7.75 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 61.27 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 74 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of $166.37 (Table 60), with a NPW of $165.89 per acre (Table 56). This financially optimal rotation would produce an estimated 5,171.83 cubic feet of pulpwood and 6.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 57.30 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 74 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of -$75.08 (Table 60), with a NPW of -$75.05 per acre (Table 56). This financially optimal rotation would produce an estimated 5,171.83 cubic feet of pulpwood and 6.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 57.30 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of -$189.17 (Table 60), with a NPW of -$189.16 per acre (Table 56). This financially optimal rotation would produce an estimated 5,381.26 cubic feet of pulpwood and 5.20 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 56.89 net tons of carbon per acre during one rotation (Table 48).

Red maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 52). This optimal management regime will generate the maximum SEV of -$250.39 (Table 60), with a NPW of -$250.39 per acre (Table 56). This financially optimal rotation would

produce an estimated 5,381.26 cubic feet of pulpwood and 5.20 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 56.89 net tons of carbon per acre during one rotation (Table 48).

Literature Review

Red Pine (*Pinus resinosa*)

Biological Information

Red pine is one of the most extensively planted species in the northern United States and Canada. Mature red pines generally reach 70 to 80 feet in height, with d.b.h. of up to 36 inches. The native range is in a narrow zone around the Great Lakes and the St. Lawrence River, most of it within or adjacent to the area glaciated during the late Pleistocene (Rudolf 2004).

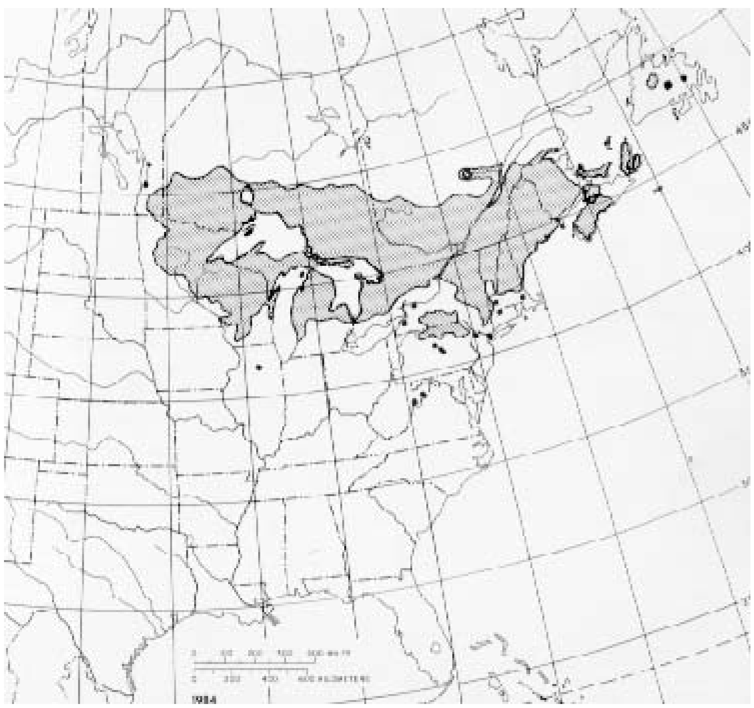

Fig1. The native range of red pine

Average annual precipitation across its range varies from 20 to 40 inches, and the frost free period ranges from 80 to 160 days (Rudolf 2004). Natural stands are largely confined to locations with sandy coarse loam soil, and grow only sporadically on heavier soils (LORC 1999). Optimum plantation development is generally made on soils that range from moderately drained to those without substantial moisture stress. In the Lake States red pine is most commonly found on level or gently rolling sand plains or ridges adjacent to lakes and swamps, at elevations ranging from 800 to 1400 feet (Rudolf 2004).

In the northern Lake States red pine grows in extensive pure stands, however it is more often found with jack pine (*Pinus banksiana*), eastern white pine (*P. strobus*), or both. It is a frequent component in three forest cover types: Red Pine (Type 15), Jack Pine (Type 1), and Eastern White Pine (Type 21), and is occasionally associated with Northern Pin Oak (*Quercus ellipsoidalis*) (Type 14). It is often found in association with jack pine, quaking aspen (*Populus tremuloides*), bigtooth aspen (*P. grandidentata*), and scrubby oaks (most commonly bear oak *(Quercus ilicifolia)*)(Rudolf 2004).

In nature, red pine stands generally become established following fire, which is the only natural agent capable of providing the majority of conditions required for reproduction. Such conditions include, open areas with very little litter or sod, and a minimum of 35 percent full sunlight. Red pine is typically tall and slender with a smooth, straight, clear bole of little taper. Eighty percent of the above ground dry weight of a tree is accounted for by the bole. Site indices range from 45 to 90 feet (base age 50) within the Lake States. Beginning at approximately 25 years of age red pine begins to self prune, and in fact prunes itself better than any other northern conifer except tamarack. Red pine is intolerant of competition and grows best in even-aged groups or stands (Rudolf 2004).

Economic Background

Red pine commands higher prices than any other Lake States' softwood species, but makes up only 2.5 percent of the regions commercial forests (Lothner and Bradley

1984). Well managed plantations can produce over a cord per acre per year in the first 40 years, and at least 700 board feet per year afterwards (Beaufeaux and Cunningham 1983). During the 1990's markets for small diameter pulpwood in southern Ontario were poor, however recent improvements in processing technologies have improved this situation (LORC 1999). Red pine revenues from state lands in Michigan grew between 1993 and 2001 from slightly under $1 million to over $5.6 million. In recent years, red pine revenues have accounted for over one-fifth of Michigan's timber revenue. In Michigan red pine comprises 7% of the cover type on State Forestlands, but makes up over 20% of timber sale revenues. On a per cord basis in 2001, red pine was worth just under $67 (MDNR 2004).

Red pine produces high quality timber, and is used for a wide variety of products. These products include, lumber, piling, poles, cabin logs, railway ties, posts, mine timbers, box boards, pulpwood and fuel (Rudolf 2004). Other uses include oriented strand board, decking, and landscape timbers (MDNR 2004). No data were found indicating types or amounts of exports of red pine.

Optimal management of red pine indicates that rotation lengths should be between 55 and 65 years, for site indices ranging from 60 to 80 (Table 1) with surviving initial stand density of 400 trees per acre (Lothner and Bradley 1984).

Table 1.—Red pine management strategies achieving a maximum internal rate of return on site indices 60, 70, and 80 for a saw log and chip market (Lothner and Bradley 1984)

Site index	IRR	Rotation age	Initial stand density	Residual basal area	Total output	Mean annual increment
	Percent	*Years*	*Trees/acre*	*Ft²/acre*	*Cunits*	*Ft³/acre/y*
60	5.0	55-65	400	80	59	107
70	6.0	60	400	80	83	138
80	7.0	55	400	80	93	169

Site preparation for red pine usually includes an herbicide application, or a prescribed burn (Beaufeaux and Cunningham 1983). Planting is typically done in single furrows, using a tree planting machine with scalpers (Knighton 1972). In general, red pine is planted during the spring before the seedlings begin to exhibit any kind of growth (LORC 1999). Initial planting densities vary, with a range from 400 to 1000 trees per acre (Lothner and Bradley 1984, MDNR, 2004). Lothner and Bradley suggest planting such that seedling survival equals 400 trees per acre. The Michigan Department of Natural Resources recommends an initial stocking of 1000 trees per acre. The most common stocking levels are from 600 to 1000 trees, with typical mortality rates ranging up to fifteen percent until the first thinning (Erickson 1996).

First thinnings in red pine stands are generally conducted between 20 and 30 years of age (LORC 1999, Lundgren 1981). Typically first and second thinnings are conducted as row thins, in which every third row is removed (LORC 1999). Following the initial thin, thinnings should be conducted on 10 year intervals (Lundgren 1981). The recommended residual basal area after thinning, regardless of which thin, is 80 to 100 square feet per acre, for site index 60 and 80 respectively (Lothner and Bradley 1984, Cooley 1969). Recommended trees per acre by average diameter class can be seen in Table 2 (Beaufeaux and Cunningham 1983).

Table 2. Recommended trees per acre by average diameter

Average Diameter 4.5 feet Above Ground	Trees per Acre
4”	900
6”	450
8”	300
10”	220
12”	170
14”	130
16”	110
18”	90
20”	75

The dry weight equation for red pine is as follows: Ln (bole wood + bark) =0.496+2.017(Ln X) (Gower et al. 1991).

Where:

Ln = natural log
X = stem diameter at breast height (in.)

Information was not found concerning number of mills or mill production in the area of interest. Minimum cutting volumes for red pine were also not found. Some of this information may yet be found in the literature, however some may only be found through contacting professionals.

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Species ___red pine___________ Region ______Lake States__________________

Site indices 50, 60 and 70 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 2.55, 4.75, and 9.35 from low to high site index. Sawlog volume was measured in International 1/4 to a 7.6-in. inside bark top diameter for trees with a minimum of 9 in diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 8-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 15 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a “thinning and final harvest” regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 100 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.204599904 and 0.479156684, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Gower et al. (1991) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$\mathrm{Log}_{10} = 0.496+2.017\log10X$$

where:

Y = dry weight (lb) stemwood + bark

X = diameter at breast height (in.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.4% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisors 200X). The price of sawtimber was assumed to be \$153/mbf (International 1/4) (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005) and pulpwood price was assumed to be \$41.83/cord (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005). The price of carbon was assumed to be \$0, \$10, \$37 or \$50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of red pine plantations in the Lake States.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (600 seedlings/ac)	$180.00	Only Once	Year 0	
Burning[a]	$21.24	Every 5 years	Year 10	Final Harvest
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]Data from Gary Kronrad, personal communications, Stephen F. Austin State University, January 27,2006.

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Table 1. Total tons of carbon sequestered per acre for red pine plantations in the lake states United States by site index and real alternative rates of return. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	16.99	17.70	16.87	16.87	16.87	16.87
60	17.19	18.47	16.23	16.23	16.23	16.23
70	18.34	17.75	15.69	15.69	15.69	15.69

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for red pine plantations in the lake states United States by site index and real alternative rates of return. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	19.89	18.96	16.90	16.87	16.87	16.87
60	17.19	18.47	16.92	16.23	16.23	16.23
70	17.06	16.83	16.02	15.69	15.69	15.69

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for red pine plantations in the lakes states United States by site index and real alternative rates of return. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	19.89	16.99	16.56	16.15	16.15	15.80
60	17.19	16.81	15.98	15.98	16.86	16.86
70	17.06	16.83	16.44	16.44	16.44	16.44

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for red pine plantations in the lake states United States by site index and real alternative rates of return. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	20.65	16.99	16.99	19.97	16.56	16.56
60	17.19	17.19	15.98	15.98	15.98	15.98
70	17.06	17.06	16.83	16.44	16.44	16.44

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for fed pine plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	**54**[2]	<30-40-**49**> (30%)[3]	<30-35-**45**>[4] (30%)	<30-35-**45**> (30%)	<30-35-**45**> (30%)	<30-35-**45**> (30%)
60	**44**	<22-29-**44**> (30%)	<22-27-**37**> (30%)	<22-27-**37**> (30%)	<22-27-**37**> (30%)	<22-27-**37**> (30%)
70	17-23-**39** (30%)	17-23-**37** (30%)	<16-21-**31**> (30%)	<16-21-**31**> (30%)	<16-21-**31**> (30%)	<16-21-**31**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red pine plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	30-41-**59**[2] (30%)	<30-40-**54**> (30%)[3]	<30-40-**46**>[4] (30%)	<30-35-**45**> (30%)	<30-35-**45**> (30%)	<30-35-**45**> (30%)
60	**44**	<22-29-**44**> (30%)	<22-28-**39**> (30%)	<22-27-**37**> (30%)	<22-27-**37**> (30%)	<22-27-**37**> (30%)
70	**38**	17-23-**33** (25%)	<16-21-**32**> (30%)	<16-21-**31**> (30%)	<16-21-**31**> (30%)	<16-21-**31**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red pine plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	30-41-**59**[2] (30%)[3]	**49**	<**47**>[4]	<**45**>	<**45**>	<**44**>
60	**44**	**42**	**39**	<**39**>	<24-30-**39**> (30%)	<24-30-**39**> (30%)
70	**38**	17-23-**33** (25%)	17-23-**33** (25%)	17-23-**33** (25%)	17-23-**33** (25%)	<17-23-**32**> (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for red pine plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	46-50-**64**[2] (30%)[3]	**49**	**49**	<45-50-**61**>[4] (30%)	<**47**>	<**47**>
60	**44**	**44**	**39**	**39**	**39**	<**39**>
70	**38**	**38**	17-23-**33** (25%)	17-23-**33** (25%)	17-23-**33** (25%)	17-23-**32** (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for red pine plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	$103.80	-$272.83	-$381.51	-$417.59	-$428.60	-$431.05
60	$330.28	-$156.31	-$309.73	-$376.10	-$404.95	-$417.51
70	$654.21	$42.19	-$185.87	-$296.81	-$354.18	-$384.67

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for red pine plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	$345.31	-$140.69	-$280.62	-$338.04	-$365.29	-$379.83
60	$520.54	-$5.84	-$194.34	-$278.89	-$323.26	-$348.17
70	$833.99	$194.37	-$58.73	-$185.27	-$256.45	-$298.55

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for red pine plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	$844.52	$233.54	-$0.34	-$121.01	-$193.48	-$241.09
60	$1,034.25	$408.64	$132.52	-$13.60	-$102.29	-$160.84
70	$1,357.89	$611.93	$299.58	$121.64	$9.76	-$65.11

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for red pine plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	$1,128.45	$419.18	$141.20	-$15.20	-$109.05	-$173.46
60	$1,281.58	$624.50	$297.80	$122.00	$9.60	-$67.51
70	$1,510.14	$860.39	$477.01	$272.30	$140.86	$49.73

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for red pine plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	$146.39	-$298.89	-$395.72	-$422.86	-$430.51	-$431.75
60	$492.35	-$175.89	-$330.92	-$386.44	-$409.61	-$419.58
70	$1,042.45	$50.03	-$206.25	-$311.56	-$362.55	-$389.12

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for red pine plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	$446.88	-$151.00	-$290.32	-$342.31	-$366.92	-$380.44
60	$775.97	-$6.57	-$205.74	-$286.55	-$326.98	-$349.90
70	$1,348.93	$240.07	-$64.67	-$194.48	-$262.51	-$302.00

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for red pine plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	$1,092.92	$255.86	-$0.35	-$122.54	-$194.34	-$241.54
60	$1,541.75	$465.80	$140.30	-$13.90	-$103.22	-$161.44
70	$2,196.31	$755.80	$329.91	$127.11	$9.97	-$65.76

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for red pine plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
50	$1,412.13	$459.23	$145.10	-$15.24	-$109.43	-$173.67
60	$1,910.46	$702.71	$315.27	$124.76	$9.68	-$67.77
70	$2,604.31	$1,011.21	$521.62	$284.55	$143.81	$50.23

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for red pine plantations by soil productivity and real alternative rates of return in the lake states United States. (carbon value = $0/ton)

Site Index[1]	ARR	Schedule	1st thinning		2nd thinning		Final Harvest		Total Volume	
			Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
50	2.50%	**49**[3]	-[5]	-	-	-	1,943.12	9.65	1,943.12	9.65
	5.00%	30-40-**49**(30%)[4]	566.17	0	449.13	1.53	1,087.01	8.37	2,102.31	9.90
	7.50%	30-35-**45**(30%)	566.17	0	655.83	0	1,050.95	7.55	2,272.95	7.55
	10.00%	30-35-**45**(30%)	566.17	0	655.83	0	1,050.95	7.55	2,272.95	7.55
	12.50%	30-35-**45**(30%)	566.17	0	655.83	0	1,050.95	7.55	2,272.95	7.55
	15.00%	30-35-**45**(30%)	566.17	0	655.83	0	1,050.95	7.55	2,272.95	7.55
60	2.50%	**44**	-	-	-	-	2,220.25	11.73	2,220.25	11.73
	5.00%	22-29-**44**(30%)	552.01	0	803.02	0	1,120.88	12.54	2,475.91	12.54
	7.50%	22-27-**37**(30%)	552.01	0	683.53	0	1,120.27	8.33	2,355.81	8.33
	10.00%	22-27-**37**(30%)	552.01	0	683.53	0	1,120.27	8.33	2,355.81	8.33
	12.50%	22-27-**37**(30%)	552.01	0	683.53	0	1,120.27	8.33	2,355.81	8.33
	15.00%	22-27-**37**(30%)	552.01	0	683.53	0	1,120.27	8.33	2,355.81	8.33
70	2.50%	17-23-**39**(30%)	708.63	0	882.28	0	1,271.75	15.97	2,862.66	15.97
	5.00%	17-23-**37**(30%)	708.63	0	882.28	0	1,242.14	14.50	2,833.05	14.50
	7.50%	16-21-**31**(30%)	608.81	0	792.70	0	1,281.79	10.01	2,683.30	10.01
	10.00%	16-21-**31**(30%)	608.81	0	792.70	0	1,281.79	10.01	2,683.30	10.01
	12.50%	16-21-**31**(30%)	608.81	0	792.70	0	1,281.79	10.01	2,683.30	10.01
	15.00%	16-21-**31**(30%)	608.81	0	792.70	0	1,281.79	10.01	2,683.30	10.01

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 18. Volume removed from the financially optimal schedules for red pine plantations by soil productivity and real alternative rates of return in the lake states United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
50	2.50%	30-41-**59**[3](30%)[4]	566.17	0	436.47	1.61	964.10	13.54	1,966.74	14.70
	5.00%	30-40-**54**(30%)	566.17	0	449.13	1.53	928.25	11.14	1,943.55	12.67
	7.50%	30-40-**46**(30%)	566.17	0	449.13	1.53	1,018.23	7.30	2,033.53	8.83
	10.00%	30-25-**45**(30%)	566.17	0	655.83	0	1,050.95	7.55	2,272.95	7.55
	12.50%	30-25-**45**(30%)	566.17	0	655.83	0	1,050.95	7.55	2,272.95	7.55
	15.00%	30-25-**45**(30%)	566.17	0	655.83	0	1,050.95	7.55	2,272.95	7.55
60	2.50%	**44**	-[5]	-	-	-	2,220.25	11.73	2,220.25	11.73
	5.00%	22-29-**44**(30%)	552.01	0	803.02	0	1,120.88	12.64	2,475.91	12.64
	7.50%	22-28-**39**(30%)	552.01	0	740.77	0	1,129.31	9.50	2,422.09	9.50
	10.00%	22-27-**37**(30%)	552.01	0	683.53	0	1,120.27	8.33	2,355.81	8.33
	12.50%	22-27-**37**(30%)	552.01	0	683.53	0	1,120.27	8.33	2,355.81	8.33
	15.00%	22-27-**37**(30%)	552.01	0	683.53	0	1,120.27	8.33	2,355.81	8.33
70	2.50%	**38**	-	-	-	-	2,984.14	13.11	2,984.14	13.11
	5.00%	17-23-**33**(25%)	570.55	0	789.36	0	1,494.68	11.69	2,854.59	11.69
	7.50%	16-21-**32**(30%)	608.81	0	792.70	0	1,248.54	10.90	2,650.05	10.90
	10.00%	16-21-**31**(30%)	608.81	0	792.70	0	1,281.79	10.01	2,683.30	10.01
	12.50%	16-21-**31**(30%)	608.81	0	792.70	0	1,281.79	10.01	2,683.30	10.01
	15.00%	16-21-**31**(30%)	608.81	0	792.70	0	1,281.79	10.01	2,683.30	10.01

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]**Indicates no operation conducted.**

Table 19. Volume removed from the financially optimal schedules for red pine plantations by soil productivity and real alternative rates of return in the lake states United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
50	2.50%	30-41-**59**[3](30%)[4]	566.17	0	436.47	1.61	964.10	13.54	1,966.74	15.15
	5.00%	**49**	-[5]	-	-	-	1,943.12	9.65	1,943.12	9.65
	7.50%	**47**	-	-	-	-	2,035.98	8.69	2,035.98	8.69
	10.00%	**45**	-	-	-	-	2,050.51	7.82	2,050.51	7.82
	12.50%	**45**	-	-	-	-	2,050.51	7.82	2,050.51	7.82
	15.00%	**44**	-	-	-	-	2,083.86	7.10	2,083.86	7.10
60	2.50%	**44**	-	-	-	-	2,220.25	11.73	2,220.25	11.73
	5.00%	**42**	-	-	-	-	2,309.34	10.63	2,309.34	10.63
	7.50%	**39**	-	-	-	-	2,415.02	8.80	2,415.02	8.80
	10.00%	**39**	-	-	-	-	2,415.02	8.80	2,415.02	8.80
	12.50%	24-30-**39**(30%)	660.63	0	802.82	0	1,107.51	8.91	2,570.96	8.91
	15.00%	24-30-**39**(30%)	660.63	0	802.82	0	1,107.51	8.91	2,570.96	8.91
70	2.50%	**38**	-	-	-	-	2,984.14	13.11	2,984.14	13.11
	5.00%	17-23-**33**(25%)	570.55	0	789.36	0	1,494.68	11.69	2,854.59	11.69
	7.50%	17-23-**33**(25%)	570.55	0	789.36	0	1,512.43	10.91	2,872.34	10.91
	10.00%	17-23-**33**(25%)	570.55	0	789.36	0	1,512.43	10.91	2,872.34	10.91
	12.50%	17-23-**33**(25%)	570.55	0	789.36	0	1,512.43	10.91	2,872.34	10.91
	15.00%	17-23-**33**(25%)	570.55	0	789.36	0	1,512.43	10.91	2,872.34	10.91

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]**Indicates no operation conducted.**

Table 20. Volume removed from the financially optimal schedules for red pine plantations by soil productivity and real alternative rates of return in the lake states United States. (carbon value = $50/ton)

Site Index[1]	ARR	Schedule	1st thinning		2nd thinning		Final Harvest		Total Volume	
			Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
50	2.50%	45-50-**64**[3](30%)[4]	692.32	1.51	363.90	2.28	881.29	13.04	1,937.51	16.83
	5.00%	**49**	-[5]	-	-	-	1,943.12	9.65	1,943.12	9.65
	7.50%	**49**	-	-	-	-	1,943.12	9.65	1,943.12	9.65
	10.00%	45-50-**61**(30%)	692.32	1.51	363.90	2.28	794.58	11.82	1,850.80	15.61
	12.50%	**47**	-	-	-	-	2,035.98	8.69	2,035.98	8.69
	15.00%	**47**	-	-	-	-	2,035.98	8.69	2,035.98	8.69
60	2.50%	**44**	-	-	-	-	2,220.25	11.73	2,220.25	11.73
	5.00%	**44**	-	-	-	-	2,220.25	11.73	2,220.25	11.73
	7.50%	**39**	-	-	-	-	2,415.02	8.80	2,415.02	8.80
	10.00%	**39**	-	-	-	-	2,415.02	8.80	2,415.02	8.80
	12.50%	**39**	-	-	-	-	2,415.02	8.80	2,415.02	8.80
	15.00%	**39**	-	-	-	-	2,415.02	8.80	2,415.02	8.80
70	2.50%	**38**	-	-	-	-	2,984.14	13.11	2,984.14	13.11
	5.00%	**38**	-	-	-	-	2,984.14	13.11	2,984.14	13.11
	7.50%	17-23-**33**(25%)	570.55	0	789.36	0	1,494.68	11.69	2,854.59	11.69
	10.00%	17-23-**32**(25%)	570.55	0	789.36	0	1,512.12	10.91	2,872.03	10.91
	12.50%	17-23-**32**(25%)	570.55	0	789.36	0	1,512.12	10.91	2,872.03	10.91
	15.0%	17-23-**32**(25%)	570.55	0	789.36	0	1,512.12	10.91	2,872.03	10.91

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]**Indicates no operation conducted.**

Table 21. Financially optimal thinning and final harvest schedules for red pine plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	50	**54**	30-41-**59** (30%)	9%	30-41-**59** (30%)	9%	46-50-**64** (30%)	19%
	60	**44**	**44**	0%	**44**	0%	**44**	0%
	70	17-23-**39** (30%)[3]	**38**	-3%	**38**	-3%	**38**	-3%
5.00%	50	<30-40-**49**>[4] (30%)	<30-40-**54**> (30%)	10%	**49**	0%	**49**	0%
	60	<22-29-**44**> (30%)	<22-29-**44**> (30%)	0%	**42**	-5%	**44**	0%
	70	17-23-**37** (30%)	17-23-**33** (25%)	-11%	17-23-**33** (25%)	-11%	**38**	5%
7.50%	50	<30-35-**45**> (30%)	<30-40-**46**> (30%)	2%	<**47**>	4%	**49**	9%
	60	<22-27-**37**> (30%)	<22-28-**39**> (30%)	5%	**39**	5%	**39**	5%
	70	<16-21-**31**> (30%)	<16-21-**32**> (30%)	3%	17-23-**33** (25%)	6%	17-23-**33** (25%)	6%
10.00%	50	<30-35-**45**> (30%)	<30-35-**45**> (30%)	0%	<**45**>	0%	<45-50-**61**> (30%)	36%
	60	<22-27-**37**> (30%)	<22-27-**37**> (30%)	0%	<**39**>	5%	**39**	5%
	70	<16-21-**31**> (30%)	<16-21-**31**> (30%)	0%	17-23-**33** (25%)	6%	17-23-**33** (25%)	6%
12.50%	50	<30-35-**45**> (30%)	<30-35-**45**> (30%)	0%	<**45**>	0%	<**47**>	4%
	60	<22-27-**37**> (30%)	<22-27-**37**> (30%)	0%	<24-30-**39**> (30%)	5%	**39**	5%
	70	<16-21-**31**> (30%)	<16-21-**31**> (30%)	0%	17-23-**33** (25%)	6%	17-23-**33** (25%)	6%
15.00%	50	<30-35-**45**> (30%)	<30-35-**45**> (30%)	0%	<**44**>	-2%	<**47**>	4%
	60	<22-27-**37**> (30%)	<22-27-**37**> (30%)	0%	<24-30-**39**> (30%)	5%	<**39**>	5%
	70	<16-21-**31**> (30%)	<16-21-**31**> (30%)	0%	<17-23-**32**> (25%)	3%	17-23-**32** (25%)	3%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3] Number in parentheses indicates the percentage of basal area removed during thinning
[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for red pine plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	50	146.39	446.88	205%	1,092.92	647%	1,412.13	865%
	60	492.35	775.97	58%	1,541.75	213%	1,910.46	288%
	70	1,042.45	1,348.93	29%	2,196.31	111%	2,604.31	150%
5.00%	50	-298.89	-151.00		255.86		459.23	
	60	-175.89	-6.57		465.80		702.71	
	70	50.03	240.07		755.80		1,011.21	
7.50%	50	-395.72	-290.32		-0.35		145.10	
	60	-330.92	-205.74		140.30		315.27	
	70	-206.25	-64.67		329.91		521.62	
10.00%	50	-422.86	-342.31		-122.54		-15.24	
	60	-386.44	-286.55		-13.90		124.76	
	70	-311.56	-194.48		127.11		284.55	
12.50%	50	-430.51	-366.92		-194.34		-109.43	
	60	-409.61	-326.98		-103.22		9.68	
	70	-362.55	-262.51		9.97		143.81	
15.00%	50	-431.75	-380.44		-241.54		-173.67	
	60	-419.58	-349.90		-161.44		-67.77	
	70	-389.12	-302.00		-65.76		50.23	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

Lake States- Red pine - Timber Only Rotations (C = $0/ton)

Red pine, Site Index 50 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 54 (Table 5). This optimal management regime will generate the maximum SEV of $146.39 (Table 13), with a NPW of $103.80 per acre (Table 9). This means that $146.39 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $103.80 per acre for managing one rotation, or $146.39 per acre from managing an infinite number of rotations. This financially optimal rotation could produce an estimated 1,943.12 cubic feet of pulpwood and 9.65 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 16.99 tons of carbon per acre during the rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red pine, Site Index 50 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 5). This optimal management regime will generate the maximum SEV of -$298.89 (Table 13), with a NPW of -$272.83 per acre (Table 9). This financially optimal rotation could produce an estimated 2,102.31 cubic feet of pulpwood and 9.90 MBF of sawlog per acre

from the thinning and final harvest (Table 17), and sequester 17.70 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 50 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 45 (Table 5). This optimal management regime will generate the maximum SEV of -$395.72 (Table 13), with a NPW of -$381.51 per acre (Table 9). This financially optimal rotation could produce an estimated 2,272.95 cubic feet of pulpwood and 7.55 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 16.87 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 50 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 45 (Table 5). This optimal management regime will generate the maximum SEV of -$422.86 (Table 13), with a NPW of -$417.59 per acre (Table 9). This financially optimal rotation could produce an estimated 2,272.95 cubic feet of pulpwood and 7.55 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 16.87 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 50 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 45 (Table 5). This optimal management regime will generate the maximum SEV of -$430.51 (Table 13), with a NPW of -$428.60 per acre (Table 9). This financially optimal rotation could produce an estimated 2,272.95 cubic feet of pulpwood and 7.55 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 16.87 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 50 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 45 (Table 5). This optimal management regime will generate the maximum SEV of -$431.75 (Table 13), with a NPW of -$431.05 per acre (Table 9). This financially optimal rotation could produce an estimated 2,272.95 cubic feet of pulpwood and 7.55 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 16.87 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 44 (Table 5). This optimal management regime will generate the maximum SEV of $492.35 (Table 13), with a NPW of $330.28 per acre (Table 9). This financially optimal rotation could produce an estimated 2,220.25 cubic feet of pulpwood and 11.73 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 17.19 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 22 and 29 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 44 (Table 5). This optimal management regime will generate the maximum SEV of -$175.89 (Table 13), with a NPW of -$156.31 per acre (Table 9). This financially optimal rotation could produce an estimated 2,475.91 cubic feet of pulpwood and 12.54 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 18.47 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 22 and 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 37 (Table 5). This optimal management regime will generate the maximum SEV of -$330.92 (Table 13), with a NPW of -$309.73 per acre (Table 9). This financially optimal rotation could produce an estimated 2,355.81 cubic feet of pulpwood and 8.33 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 16.23 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 22 and 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 37 (Table 5). This optimal management regime will generate the maximum SEV of -$386.44 (Table

13), with a NPW of -$376.10 per acre (Table 9). This financially optimal rotation could produce an estimated 2,355.81 cubic feet of pulpwood and 8.33 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 16.23 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 22 and 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 37 (Table 5). This optimal management regime will generate the maximum SEV of -$409.61 (Table 13), with a NPW of -$404.95 per acre (Table 9). This financially optimal rotation could produce an estimated 2,355.81 cubic feet of pulpwood and 8.33 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 16.23 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 22 and 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 37 (Table 5). This optimal management regime will generate the maximum SEV of -$419.58 (Table 13), with a NPW of -$417.51 per acre (Table 9). This financially optimal rotation could produce an estimated 2,355.81 cubic feet of pulpwood and 8.33 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 16.23 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 17 and 23 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 39 (Table 5). This optimal management regime will generate the maximum SEV of $1,042.45 (Table 13), with a NPW of $654.21 per acre (Table 9). This financially optimal rotation could produce an estimated 2,862.66 cubic feet of pulpwood and 15.97 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 18.34 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 17 and 23 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 37 (Table 5). This optimal management regime will generate the maximum SEV of $50.03 (Table 13), with a NPW of $42.19 per acre (Table 9). This financially optimal rotation could produce an estimated 2,833.05 cubic feet of pulpwood and 14.50 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 17.75 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 16 and 21 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 31 (Table 5). This optimal management regime will generate the maximum SEV of -$206.25 (Table 13), with a NPW of -$185.87 per acre (Table 9). This financially optimal rotation could

produce an estimated 2,683.30 cubic feet of pulpwood and 10.01 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 15.69 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 16 and 21 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 31 (Table 5). This optimal management regime will generate the maximum SEV of -$311.56 (Table 13), with a NPW of -$296.81 per acre (Table 9). This financially optimal rotation could produce an estimated 2,683.30 cubic feet of pulpwood and 10.01 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 15.69 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 16 and 21 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 31 (Table 5). This optimal management regime will generate the maximum SEV of -$362.55 (Table 13), with a NPW of -$354.18 per acre (Table 9). This financially optimal rotation could produce an estimated 2,683.30 cubic feet of pulpwood and 10.01 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 15.69 tons of carbon per acre during the rotation (Table 1).

Red pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 16 and 21 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 31 (Table 5). This optimal management regime will generate the maximum SEV of -$389.12 (Table 13), with a NPW of -$384.67 per acre (Table 9). This financially optimal rotation could produce an estimated 2,683.30 cubic feet of pulpwood and 10.01 MBF of sawlog per acre from the thinning and final harvest (Table 17), and sequester 15.69 tons of carbon per acre during the rotation (Table 1).

Lake States- Red pine - Timber Plus Carbon Rotations (C = $10/ton)

Red pine, Site Index 50 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 6). This optimal management regime will generate the maximum SEV of $446.88 (Table 14), with a NPW of $345.31 per acre (Table 10). This means that $446.88 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $345.31 per acre for managing one rotation, or $446.88 per acre from managing an infinite number of rotations. This financially optimal rotation could produce an estimated 1,966.74 cubic feet of pulpwood and 14.70 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 19.89 tons of carbon per acre during the rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red pine, Site Index 50 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 6). This optimal management regime will generate the maximum SEV of -$151.00 (Table 14), with a NPW of -$140.69 per acre (Table 10). This financially optimal rotation could produce an estimated 1,943.55 cubic feet of pulpwood and 12.67 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 18.96 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 50 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 6). This optimal management regime will generate the maximum SEV of -$290.32 (Table 14), with a NPW of -$280.62 per acre (Table 10). This financially optimal rotation could produce an estimated 2,033.53 cubic feet of pulpwood and 8.83 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 16.90 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 50 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 45 (Table 6). This optimal management regime will generate the maximum SEV of -$342.31 (Table 14), with a NPW of -$338.04 per acre (Table 10). This financially optimal rotation could produce an estimated 2,272.95 cubic feet of pulpwood and 7.55 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 16.87 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 50 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 45 (Table 6). This optimal management regime will generate the maximum SEV of -$366.92 (Table 14), with a NPW of -$365.29 per acre (Table 10). This financially optimal rotation could produce an estimated 2,272.95 cubic feet of pulpwood and 7.55 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 16.87 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 50 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 45 (Table 6). This optimal management regime will generate the maximum SEV of -$380.44 (Table 14), with a NPW of -$379.83 per acre (Table 10). This financially optimal rotation could produce an estimated 2,272.95 cubic feet of pulpwood and 7.55 MBF of sawlog per acre

from the thinning and final harvest (Table 18), and sequester 16.87 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 44 (Table 6). This optimal management regime will generate the maximum SEV of $775.97 (Table 14), with a NPW of $520.54 per acre (Table 10). This financially optimal rotation could produce an estimated 2,220.25 cubic feet of pulpwood and 11.73 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 17.19 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 22 and 29 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 44 (Table 6). This optimal management regime will generate the maximum SEV of -$6.57 (Table 14), with a NPW of -$5.84 per acre (Table 10). This financially optimal rotation could produce an estimated 2,475.91 cubic feet of pulpwood and 12.64 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 18.47 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 22 and 28 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 39 (Table 6). This optimal management regime will generate the maximum SEV of -\$205.74 (Table 14), with a NPW of -\$194.34 per acre (Table 10). This financially optimal rotation could produce an estimated 2,422.09 cubic feet of pulpwood and 9.50 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 16.92 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 22 and 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 37 (Table 6). This optimal management regime will generate the maximum SEV of -\$286.55 (Table 14), with a NPW of -\$278.89 per acre (Table 10). This financially optimal rotation could produce an estimated 2,355.81 cubic feet of pulpwood and 8.33 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 16.23 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 22 and 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 37 (Table 6). This optimal management regime will generate the maximum SEV of -\$326.98 (Table 14), with a NPW of -\$323.26 per acre (Table 10). This financially optimal rotation could produce an estimated 2,355.81 cubic feet of pulpwood and 8.33 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 16.23 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 22 and 27 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 37 (Table 6). This optimal management regime will generate the maximum SEV of -$349.90 (Table 14), with a NPW of -$348.17 per acre (Table 10). This financially optimal rotation could produce an estimated 2,355.81 cubic feet of pulpwood and 8.33 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 16.23 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 38 (Table 6). This optimal management regime will generate the maximum SEV of $1,348.93 (Table 14), with a NPW of $833.99 per acre (Table 10). This financially optimal rotation could produce an estimated 2,984.14 cubic feet of pulpwood and 13.11 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 17.06 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 17 and 23 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 6). This optimal management regime will generate the maximum SEV of $240.07 (Table 14), with a NPW of $194.37 per acre (Table 10). This financially optimal rotation could

produce an estimated 2,854.59 cubic feet of pulpwood and 11.69 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 16.83 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 16 and 21 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 32 (Table 6). This optimal management regime will generate the maximum SEV of -$64.67 (Table 14), with a NPW of -$58.73 per acre (Table 10). This financially optimal rotation could produce an estimated 2,650.05 cubic feet of pulpwood and 10.90 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 16.02 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 16 and 21 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 31 (Table 6). This optimal management regime will generate the maximum SEV of -$194.48 (Table 14), with a NPW of -$185.27 per acre (Table 10). This financially optimal rotation could produce an estimated 2,683.30 cubic feet of pulpwood and 10.01 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 15.69 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 16 and 21 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 31 (Table 6). This optimal management regime will generate the maximum SEV of -$262.51 (Table 14), with a NPW of -$256.45 per acre (Table 10). This financially optimal rotation could produce an estimated 2,683.30 cubic feet of pulpwood and 10.01 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 15.69 tons of carbon per acre during the rotation (Table 2).

Red pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 16 and 21 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 31 (Table 6). This optimal management regime will generate the maximum SEV of -$302.00 (Table 14), with a NPW of -$298.55 per acre (Table 10). This financially optimal rotation could produce an estimated 2,683.30 cubic feet of pulpwood and 10.01 MBF of sawlog per acre from the thinning and final harvest (Table 18), and sequester 15.69 tons of carbon per acre during the rotation (Table 2).

<u>Lake States- Red pine - Timber Plus Carbon Rotations (C = $37/ton)</u>

Red pine, Site Index 50 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 7).

This optimal management regime will generate the maximum SEV of $1,092.92 (Table 15), with a NPW of $844.52 per acre (Table 11). This means that $1,092.92 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $844.52 per acre for managing one rotation, or $1,092.92 per acre from managing an infinite number of rotations. This financially optimal rotation could produce an estimated 1,966.74 cubic feet of pulpwood and 15.15 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 19.89 tons of carbon per acre during the rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red pine, Site Index 50 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 49 (Table 7). This optimal management regime will generate the maximum SEV of $255.86 (Table 15), with a NPW of $233.54 per acre (Table 11). This financially optimal rotation could produce an estimated 1,943.12 cubic feet of pulpwood and 9.65 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 16.99 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 50 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 47 (Table 7). This optimal management regime will generate the maximum SEV of -$0.35 (Table 15), with

a NPW of -$0.34 per acre (Table 11). This financially optimal rotation could produce an estimated 2,035.98 cubic feet of pulpwood and 8.69 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 16.56 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 50 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 45 (Table 7). This optimal management regime will generate the maximum SEV of -$122.54 (Table 15), with a NPW of -$121.01 per acre (Table 11). This financially optimal rotation could produce an estimated 2,050.51 cubic feet of pulpwood and 7.82 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 16.15 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 50 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 45 (Table 7). This optimal management regime will generate the maximum SEV of -$194.34 (Table 15), with a NPW of -$193.48 per acre (Table 11). This financially optimal rotation could produce an estimated 2,050.51 cubic feet of pulpwood and 7.82 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 16.15 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 50 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 44 (Table 7). This

optimal management regime will generate the maximum SEV of -$241.54 (Table 15), with a NPW of -$241.09 per acre (Table 11). This financially optimal rotation could produce an estimated 2,083.86 cubic feet of pulpwood and 7.10 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 15.80 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 44 (Table 7). This optimal management regime will generate the maximum SEV of $1,541.75 (Table 15), with a NPW of $1,034.25 per acre (Table 11). This financially optimal rotation could produce an estimated 2,220.25 cubic feet of pulpwood and 11.73 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 17.19 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 42 (Table 7). This optimal management regime will generate the maximum SEV of $465.80 (Table 15), with a NPW of $408.64 per acre (Table 11). This financially optimal rotation could produce an estimated 2,309.34 cubic feet of pulpwood and 10.63 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 15.98 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 39 (Table 7). This optimal management regime will generate the maximum SEV of $140.30 (Table 15), with a NPW of $132.52 per acre (Table 11). This financially optimal rotation could produce an estimated 2,415.02 cubic feet of pulpwood and 8.80 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 15.98 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 39 (Table 7). This optimal management regime will generate the maximum SEV of -$13.90 (Table 15), with a NPW of -$13.60 per acre (Table 11). This financially optimal rotation could produce an estimated 2,415.02 cubic feet of pulpwood and 8.80 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 15.98 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 24 and 30 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 39 (Table 7). This optimal management regime will generate the maximum SEV of -$103.22 (Table 15), with a NPW of -$102.29 per acre (Table 11). This financially optimal rotation could produce an estimated 2,570.96 cubic feet of pulpwood and 8.91 MBF of sawlog per acre

from the thinning and final harvest (Table 19), and sequester 16.86 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 24 and 30 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 39 (Table 7). This optimal management regime will generate the maximum SEV of -$161.44 (Table 15), with a NPW of -$160.84 per acre (Table 11). This financially optimal rotation could produce an estimated 2,570.96 cubic feet of pulpwood and 8.91 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 16.86 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 38 (Table 7). This optimal management regime will generate the maximum SEV of $2,196.31 (Table 15), with a NPW of $1,357.89 per acre (Table 11). This financially optimal rotation could produce an estimated 2,984.14 cubic feet of pulpwood and 13.11 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 17.06 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 17 and 23 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 7).

This optimal management regime will generate the maximum SEV of $755.80 (Table 15), with a NPW of $611.93 per acre (Table 11). This financially optimal rotation could produce an estimated 2,854.59 cubic feet of pulpwood and 11.69 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 16.83 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 17 and 23 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 7). This optimal management regime will generate the maximum SEV of $329.91 (Table 15), with a NPW of $299.58 per acre (Table 11). This financially optimal rotation could produce an estimated 2,872.34 cubic feet of pulpwood and 10.91 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 16.44 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 17 and 23 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 7). This optimal management regime will generate the maximum SEV of $127.11 (Table 15), with a NPW of $121.64 per acre (Table 11). This financially optimal rotation could produce an estimated 2,872.34 cubic feet of pulpwood and 10.91 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 16.44 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 17 and 23 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 7). This optimal management regime will generate the maximum SEV of $9.97 (Table 15), with a NPW of $9.76 per acre (Table 11). This financially optimal rotation could produce an estimated 2,872.34 cubic feet of pulpwood and 10.91 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 16.44 tons of carbon per acre during the rotation (Table 3).

Red pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 17 and 23 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 32 (Table 7). This optimal management regime will generate the maximum SEV of -$65.76 (Table 15), with a NPW of -$65.11 per acre (Table 11). This financially optimal rotation could produce an estimated 2,872.34 cubic feet of pulpwood and 10.91 MBF of sawlog per acre from the thinning and final harvest (Table 19), and sequester 16.44 tons of carbon per acre during the rotation (Table 3).

<u>Lake States- Red pine - Timber Plus Carbon Rotations (C = $50/ton)</u>

Red pine, Site Index 50 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 50 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 64 (Table 8). This optimal management regime will generate the maximum SEV of $1,412.13 (Table 16), with a NPW of $1,128.45 per acre (Table 12). This means that $1,412.13 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,128.45 per acre for managing one rotation, or $1,412.13 per acre from managing an infinite number of rotations. This financially optimal rotation could produce an estimated 1,937.51 cubic feet of pulpwood and 16.83 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 20.65 tons of carbon per acre during the rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Red pine, Site Index 50 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 49 (Table 8). This optimal management regime will generate the maximum SEV of $459.23 (Table 16), with a NPW of $419.18 per acre (Table 12). This financially optimal rotation could produce an estimated 1,943.12 cubic feet of pulpwood and 9.65 MBF of sawlog per acre

from the thinning and final harvest (Table 20), and sequester 16.99 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 50 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 49 (Table 8). This optimal management regime will generate the maximum SEV of $145.10 (Table 16), with a NPW of $141.20 per acre (Table 12). This financially optimal rotation could produce an estimated 1,943.12 cubic feet of pulpwood and 9.65 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 16.99 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 50 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 50 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 61 (Table 8). This optimal management regime will generate the maximum SEV of -$15.24 (Table 16), with a NPW of -$15.20 per acre (Table 12). This financially optimal rotation could produce an estimated 1,850.80 cubic feet of pulpwood and 15.61 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 19.97 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 50 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 47 (Table 8). This optimal management regime will generate the maximum SEV of -$109.43 (Table 16),

with a NPW of -$109.05 per acre (Table 12). This financially optimal rotation could produce an estimated 2,035.98 cubic feet of pulpwood and 8.69 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 16.56 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 50 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 47 (Table 8). This optimal management regime will generate the maximum SEV of -$173.67 (Table 16), with a NPW of -$173.46 per acre (Table 12). This financially optimal rotation could produce an estimated 2,035.98 cubic feet of pulpwood and 8.69 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 16.56 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 44 (Table 8). This optimal management regime will generate the maximum SEV of $1,910.46 (Table 16), with a NPW of $1,281.58 per acre (Table 12). This financially optimal rotation could produce an estimated 2,220.25 cubic feet of pulpwood and 11.73 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 17.19 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 44 (Table 8). This

optimal management regime will generate the maximum SEV of $702.71 (Table 16), with a NPW of $624.50 per acre (Table 12). This financially optimal rotation could produce an estimated 2,220.25 cubic feet of pulpwood and 11.73 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 17.19 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 39 (Table 8). This optimal management regime will generate the maximum SEV of $315.27 (Table 16), with a NPW of $297.80 per acre (Table 12). This financially optimal rotation could produce an estimated 2,415.02 cubic feet of pulpwood and 8.80 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 15.98 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 39 (Table 8). This optimal management regime will generate the maximum SEV of $124.76 (Table 16), with a NPW of $122.00 per acre (Table 12). This financially optimal rotation could produce an estimated 2,415.02 cubic feet of pulpwood and 8.80 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 15.98 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 39 (Table 8). This optimal management regime will generate the maximum SEV of $9.68 (Table 16), with a NPW of $9.60 per acre (Table 12). This financially optimal rotation could produce an estimated 2,415.02 cubic feet of pulpwood and 8.80 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 15.98 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 39 (Table 8). This optimal management regime will generate the maximum SEV of -$67.77 (Table 16), with a NPW of -$67.51 per acre (Table 12). This financially optimal rotation could produce an estimated 2,415.02 cubic feet of pulpwood and 8.80 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 15.98 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 38 (Table 8). This optimal management regime will generate the maximum SEV of $2,604.31 (Table 16), with a NPW of $1,510.14 per acre (Table 12). This financially optimal rotation could produce an estimated 2,984.14 cubic feet of pulpwood and 13.11 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 17.06 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 38 (Table 8). This optimal management regime will generate the maximum SEV of $1,011.21 (Table 16), with a NPW of $860.39 per acre (Table 12). This financially optimal rotation could produce an estimated 2,984.14 cubic feet of pulpwood and 13.11 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 17.06 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 17 and 23 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 8). This optimal management regime will generate the maximum SEV of $521.62 (Table 16), with a NPW of $477.01 per acre (Table 12). This financially optimal rotation could produce an estimated 2,854.59 cubic feet of pulpwood and 11.69 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 16.83 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 17 and 23 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 8). This optimal management regime will generate the maximum SEV of $284.55 (Table 16), with a NPW of $272.30 per acre (Table 12). This financially optimal rotation could

produce an estimated 2,872.03 cubic feet of pulpwood and 10.91 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 16.44 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 17 and 23 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 33 (Table 8). This optimal management regime will generate the maximum SEV of $143.81 (Table 16), with a NPW of $140.86 per acre (Table 12). This financially optimal rotation could produce an estimated 2,872.03 cubic feet of pulpwood and 10.91 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 16.44 tons of carbon per acre during the rotation (Table 4).

Red pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 17 and 23 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 32 (Table 8). This optimal management regime will generate the maximum SEV of $50.23 (Table 16), with a NPW of $49.73 per acre (Table 12). This financially optimal rotation could produce an estimated 2,872.03 cubic feet of pulpwood and 10.91 MBF of sawlog per acre from the thinning and final harvest (Table 20), and sequester 16.44 tons of carbon per acre during the rotation (Table 4).

Shortleaf pine (*Pinus echinata*)

Biological Information

Shortleaf pine is one of the most important commercial species in the southeastern United States. It is the most commonly regenerated species in the western and northern parts of its range. The range of shortleaf pine extends southwest from New York to Missouri and East Texas, and includes all of the southern states. Shortleaf pine grows best in the southern piedmont, Arkansas, and northern Louisiana (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/echinata.htm. June 2, 2006) (Fig. 1).

Fig. 1. The native range of shortleaf pine (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/echinata.htm. June 2, 2006)

In natural forest conditions site indices average between 50 and 75 feet base age 50, but can exceed 100 feet on excellent sites. On good sites trees can attain a height of 100 feet or more and diameters of 24 to 36 inches at breast height, although diameters of 48 inches have been recorded. On site index 60 land (base age 25) mean annual increment of volume culminates at approximately age 20 at about 225 cubic feet per acre. Fully stocked stands exhibit self-pruning, but typically at a slower rate than loblolly or longleaf pine (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/echinata.htm. June 2, 2006).

Shortleaf pine is classified as intolerant of competition, and does not survive or grow well when suppressed. Typically Shortleaf can endure competition longer than loblolly pine, a common associate. Even mature trees will typically respond well to release. On very good sites Shortleaf may be incapable of outgrowing competing species such as Sweetgum, requiring hardwood control to dominate the site (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/echinata.htm. June 2, 2006).

Shortleaf pine is primarily used for plywood, lumber, pulpwood, and other structural materials. Even the taproots in some instances have been harvested for pulpwood. Old growth trees with heart rot (*Phellinus pini*) are primary nesting trees for the endangered red-cockaded woodpecker (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/echinata.htm. June 2, 2006).

Economic Background

Cain and Shelton (2003) studied the effects of alternative thinning regimes and prescribed burning in natural, even-aged loblolly-shortleaf pine stands. The objective was to evaluate four thinning treatments and a control relative to growth in naturally regenerated stands. A precommercial thin was applied at age 6, followed by commercial thinnings at ages 17 and 23. Precommercial thins were conducted by mowing 12 foot wide strips alternating with 1 foot wide uncut strips, at a cost of approximately $33.22 per acre. Prescribed burning costs ranged from $4.12 in 1982 to $16.58 in 1998. Commercial thinnings were conducted either as thins from below to a residual basal area of 85 square feet per acre, or to leave 200 crop trees per acre (not to exceed 75 square feet per acre of basal area). Pine sawlog price averaged $238 per MBF, and pulpwood averaged $18.28 per cord. Net present values through 25 years were discounted at 4, 7, and 10 percent. Crop trees on precommercially thinned plots averaged over 1 inch larger in dbh than plots that were not precommercially thinned. Trees on plots thinned to 75 square feet per acre of basal area were 12% larger than plots thinned from below. Across all thinned plots trees averaged 15% larger than those in control plots. The precommercial thin, with commercial thinning to 75 square feet per acre of basal area resulted in the highest NPV regardless of the discount rate. The lowest NPV occurred with the conventional thin, with only two commercial thins to 85 square feet per acre of basal area without precommercial thinning.

Farrar et al. (1989) summarized the results of selection management on two 40-acre shortleaf pine tracts over a 25-year period. At the beginning of the management period it was decided that one tract would be harvested annually, while the other would be cut on a 5-year cutting cycle. The non-equal income from the two tracts would be converted to an equal annual equivalent (EAI) by converting the net present value using the following discount formula:

$$EAI = NPV\left\{\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]\right\}$$

where,

n = number of years in the cycle

i = annual interest rate, expressed as a decimal

At both a 5 and 10 percent discount rate the 5-year forty produced and EAI greater than the 1-year forty. Their analysis indicated that this occurred because the 5-year forty had a large initial cut that generated higher initial revenues than the 1-year forty. Both would have produced similar EAI's if similar initial cuts had been conducted.

Guldin (1985) reported estimated Shortleaf pine growth response to release. The initial release was conducted in 1955, on site index 47 base age 25 land. Stands were re-measured in 1982, and samples were taken to determine diameter increment by 5-year periods. It was found that the majority of the diameter growth response to the release occurred in the first five years following the treatment, but some response occurred during the second five years. In 1985 dollars the release of the observed stand in 1974 would have resulted in extra volume worth an additional $166.72 per acre. The present value of the release is $93.10 in 1985, therefore if a landowner invested this amount in a release he would be no worse off in 10 years than if he had invested in a money market fund.

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Species Shortleaf pine Region South

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 7-in. inside bark top diameter for trees with a minimum of 10 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 9-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 15 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 25, 30 and 35% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.194648829 and 0.668896321, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Clark and Taras (1976) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$\mathrm{Log}_{10}Y = -1.52244+1.1186\mathrm{Log}_{10}(D^2Th)$$

where:

Y = aboveground dry-weight with leaves (lbs.)

D = diameter at breast height (in.)

Th = total tree height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.6% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $296/mbf (Scribner) (Timber Mart South, Inc. 2000-2005) and pulpwood price was assumed to be $18.43/cord (Timber Mart South, Inc. 2000-2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of shortleaf pine plantations in the South.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$80.28	Only once	Year 0	
Seedlings[a] (600 seedlings/ac)	$25.81	Only Once	Year 0	
Burning[a]	$21.24	Every 5 years	Year 10	Final Harvest
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al (2005).

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Table 1. Total tons of carbon sequestered per acre for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	32.53	32.53	35.25	35.25	24.80	23.16
80	43.07	43.07	39.87	39.87	39.69	39.69
90	47.16	47.87	47.64	46.64	44.48	44.48

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	32.53	35.30	35.25	35.25	35.25	35.25
80	43.07	43.07	43.07	43.07	39.87	39.87
90	47.87	47.87	47.64	46.64	46.64	44.75

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	32.53	35.30	35.30	35.30	35.17	35.17
80	43.07	43.07	43.07	43.07	43.07	43.07
90	47.87	48.28	48.28	48.97	48.68	48.03

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	32.53	35.30	35.17	35.17	35.17	35.17
80	43.07	43.07	43.07	43.07	43.07	43.18
90	48.28	48.28	48.97	49.57	51.00	52.01

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	39-45-**60**[2] (35%)[3]	<39-45-**60>**[4](35%)	<41-**60**> (30%)	<41-**60**> (30%)	<39-**47**> (30%)	<39-**45**> (30%)
80	40-**60** (35%)	<40-**60>** (35%)	<36-42-**60**> (35%)	<36-42-**60**> (35%)	<36-41-**60**> (35%)	<36-41-**60**> (35%)
90	32-37-**60** (35%)	33-40-**60** (35%)	<34-39-**60**> (35%)	<35-40-**59**> (35%)	<33-38-**57**> (35%)	<33-38-**57**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	39-45-**60**[2] (35%)[3]	<45-**60>**[4](30%)	<41-**60**> (30%)	<41-**60**> (30%)	<41-**60**> (30%)	<41-**60**> (30%)
80	40-**60** (35%)	40-**60** (35%)	<40-**60>** (35%)	<40-**60>** (35%)	<36-42-**60**> (35%)	<36-42-**60**> (35%)
90	33-40-**60** (35%)	33-40-**60** (35%)	<34-39-**60**> (35%)	<35-40-**59**> (35%)	<35-40-**59**> (35%)	<35-40-**57**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	39-45-**60**[2] (35%)[3]	45-**60** (30%)	<45-**60**>[4](30%)	<45-**60**> (30%)	<54-**60**> (30%)	<54-**60**> (30%)
80	40-**60** (35%)	40-**60** (35%)	40-**60** (35%)	<40-**60**> (30%)	<40-**60**> (35%)	<40-**60**> (35%)
90	33-40-**60** (35%)	34-42-**60** (35%)	34-42-**60** (35%)	<37-46-**60**> (35%)	<39-49-**59**> (35%)	<43-50-**58**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	39-45-**60**[2] (35%)[3]	45-**60** (30%)	54-**60** (30%)	<54-**60**>[4] (30%)	<54-**60**> (30%)	<54-**60**> (30%)
80	40-**60** (35%)	40-**60** (35%)	40-**60** (35%)	<40-**60**> (35%)	<40-**60**> (35%)	<46-**60**> (35%)
90	34-42-**60** (35%)	34-42-**60** (35%)	37-46-**60** (35%)	42-49-**60** (35%)	<45-52-**60**> (35%)	<54-**60**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$52.59	-$241.85	-$282.01	-$290.62	-$291.20	-$291.38
80	$624.35	-$108.52	-$268.34	-$299.74	-$303.53	-$301.60
90	$1,084.82	$8.76	-$235.64	-$290.02	-$300.25	-$300.34

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$229.65	-$138.52	-$221.40	-$253.48	-$267.94	-$275.33
80	$863.80	$25.82	-$189.72	-$251.18	-$271.17	-$278.82
90	$1,351.66	$164.39	-$140.60	-$228.17	-$258.03	-$270.17

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$707.72	$147.25	-$56.96	-$152.87	-$202.52	-$230.47
80	$1,510.34	$388.57	$24.51	-$116.76	-$181.90	-$216.49
90	$2,079.06	$588.47	$118.46	-$59.80	-$142.71	-$187.79

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$937.90	$284.85	$22.33	-$103.95	-$170.78	-$208.78
80	$1,821.63	$563.22	$127.65	-$52.04	-$138.89	-$186.31
90	$2,432.46	$792.78	$245.25	$22.88	-$86.30	-$147.55

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$67.58	-$254.84	-$285.48	-$291.49	-$292.23	-$291.85
80	$802.24	-$114.36	-$271.64	-$300.64	-$303.76	-$301.66
90	$1,393.91	$9.23	-$238.53	-$290.97	-$300.58	-$300.43

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$295.09	-$145.96	-$224.12	-$254.24	-$268.14	-$275.38
80	$1,109.92	$27.21	-$192.05	-$251.93	-$271.38	-$278.87
90	$1,736.77	$173.23	-$142.33	-$228.92	-$258.25	-$270.25

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$909.36	$155.16	-$57.66	-$153.32	-$202.67	-$230.52
80	$1,940.66	$409.44	$24.81	-$117.11	-$182.04	-$216.53
90	$2,671.42	$620.08	$119.91	-$59.98	-$142.83	-$187.84

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for shortleaf pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,205.13	$300.15	$22.61	-$104.26	-$170.91	-$208.83
80	$2,340.64	$593.48	$129.22	-$52.20	-$139.00	-$186.35
90	$3,125.52	$835.37	$248.26	$22.95	-$86.37	-$147.58

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for shortleaf pine plantations by soil productivity and real alternative rates of return in the southern United States). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	39-45-**60**[3] (35%)[4]	802.42	0	930.91	0	2,309.95	4.01	4,043.28	4.01
	5.0%	39-45-**60** (35%)	802.42	0	930.91	0	2,309.95	4.01	4,043.28	4.01
	7.5%	41-**60** (30%)	850.13	0	-[5]	-	4,483.08	0.78	5,333.21	0.78
	10.0%	41-**60** (30%)	850.13	0	-	-	4,483.08	0.78	5,333.21	0.78
	12.5%	39-**47** (30%)	657.50	0	-	-	3,154.02	0	3,811.52	0
	15.0%	39-**45** (30%)	657.50	0	-	-	2,896.43	0	3,553.93	0
80	2.5%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	5.0%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	7.5%	36-42-**60** (35%)	862.83	0	1,038.92	0	1,623.53	10.06	3,525.28	10.06
	10.0%	36-42-**60** (35%)	862.83	0	1,038.92	0	1,623.53	10.06	3,525.28	10.06
	12.5%	36-41-**60** (35%)	862.83	0	989.66	0	1,715.00	9.85	3,567.49	9.85
	15.0%	36-41-**60** (35%)	862.83	0	989.66	0	1,715.00	9.85	3,567.49	9.85
90	2.5%	32-37-**60** (35%)	573.88	0	1,024.42	0	986.80	16.28	2,585.10	16.28
	5.0%	33-40-**60** (35%)	804.60	0	1,184.31	0	936.42	16.08	2,925.33	16.08
	7.5%	34-39-**60** (35%)	982.72	0	1,111.64	0	966.27	15.90	3,060.63	15.90
	10.0%	35-40-**59** (35%)	1,153.51	0	1,148.12	0	1,072.89	14.49	3,374.52	14.49
	12.5%	33-38-**57** (35%)	804.60	0	1,067.06	0	1,692.19	11.63	3,563.85	11.63
	15.0%	33-38-**57** (35%)	804.60	0	1,067.06	0	1,692.19	11.63	3,563.85	11.63

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indiates no operation conducted

Table 18. Volume removed from the financially optimal schedules for shortleaf pine plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	39-45-**60**[3] (35%)[4]	802.42	0	930.91	0	2,309.95	4.01	4,043.28	4.01
	5.0%	45-**60** (30%)	1,042.30	0	-[5]	-	4,356.59	0.79	5,398.89	0.79
	7.5%	41-**60** (30%)	850.13	0	-	-	4,483.08	0.78	5,333.21	0.78
	10.0%	41-**60** (30%)	850.13	0	-	-	4,483.08	0.78	5,333.21	0.78
	12.5%	41-**60** (30%)	850.13	0	-	-	4,483.08	0.78	5,333.21	0.78
	15.0%	41-**60** (30%)	850.13	0	-	-	4,483.08	0.78	5,333.21	0.78
80	2.5%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	5.0%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	7.5%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	10.0%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	12.5%	36-42-**60** (35%)	862.83	0	1,038.92	0	1,623.53	10.06	3,525.28	10.06
	15.0%	36-42-**60** (35%)	862.83	0	1,038.92	0	1,623.53	10.06	3,525.28	10.06
90	2.5%	33-40-**60** (35%)	804.60	0	1,184.31	0	936.42	16.08	2,925.33	16.08
	5.0%	33-40-**60** (35%)	804.60	0	1,184.31	0	936.42	16.08	2,925.33	16.08
	7.5%	34-39-**60** (35%)	982.72	0	1,111.64	0	966.27	15.90	3,060.63	15.90
	10.0%	35-40-**59** (35%)	1,153.51	0	1,148.12	0	1,072.89	14.49	3,374.52	14.49
	12.5%	35-40-**59** (35%)	1,153.51	0	1,148.12	0	1,072.89	14.49	3,374.52	14.49
	15.0%	35-40-**59** (35%)	1,153.51	0	1,148.12	0	1,617.55	11.22	3,919.18	11.22

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indiates no operation conducted

Table 19. Volume removed from the financially optimal schedules for shortleaf pine plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	39-45-**60**[3] (35%)[4]	802.42	0	930.91	0	2,309.95	4.01	4,043.28	4.01
	5.0%	45-**60** (30%)	1,042.30	0	-[5]	-	4,356.59	0.79	5,398.89	0.79
	7.5%	45-**60** (30%)	1,042.30	0	-	-	4,356.59	0.79	5,398.89	0.79
	10.0%	45-**60** (30%)	1,042.30	0	-	-	4,356.59	0.79	5,398.89	0.79
	12.5%	54-**60** (30%)	1,378.55	0	-	-	4,105.79	0.38	5,484.34	0.38
	15.0%	54-**60** (30%)	1,378.55	0	-	-	4,105.79	0.38	5,484.34	0.38
80	2.5%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	5.0%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	7.5%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	10.0%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	12.5%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	15.0%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
90	2.5%	33-40-**60** (35%)	804.60	0	1,184.31	0	936.42	16.08	2,925.33	16.08
	5.0%	34-42-**60** (35%)	982.72	0	1,281.68	0	897.96	15.86	3,162.36	15.86
	7.5%	34-42-**60** (35%)	982.72	0	1,281.68	0	897.96	15.86	3,162.36	15.86
	10.0%	37-46-**60** (35%)	1,347.08	0	1,448.81	0	967.13	14.57	3,763.02	14.57
	12.5%	39-49-**59** (35%)	1,464.48	0	1,582.90	0	1,186.77	12.56	4,234.15	12.56
	15.0%	43-50-**58** (35%)	1,702.84	0	1,572.74	0	1,541.24	9.85	4,816.82	9.85

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indiates no operation conducted

Table 20. Volume removed from the financially optimal schedules for shortleaf pine plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	39-45-**60**[3] (35%)[4]	802.42	0	930.91	0	2,309.95	4.01	4,043.28	4.01
	5.0%	45-**60** (30%)	1,042.30	0	-[5]	-	4,356.59	0.79	5,398.89	0.79
	7.5%	54-**60** (30%)	1,378.55	0	-	-	4,105.79	0.38	5,484.34	0.38
	10.0%	54-**60** (30%)	1,378.55	0	-	-	4,105.79	0.38	5,484.34	0.38
	12.5%	54-**60** (30%)	1,378.55	0	-	-	4,105.79	0.38	5,484.34	0.38
	15.0%	54-**60** (30%)	1,378.55	0	-	-	4,105.79	0.38	5,484.34	0.38
80	2.5%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	5.0%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	7.5%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	10.0%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	12.5%	40-**60** (35%)	1,261.18	0	-	-	3,989.37	5.66	5,250.55	5.66
	15.0%	46-**60** (35%)	1,573.60	0	-	-	4,018.85	4.39	5,592.45	4.39
90	2.5%	34-42-**60** (35%)	982.72	0	1,281.68	0	897.96	15.86	3,162.36	15.86
	5.0%	34-42-**60** (35%)	982.72	0	1,281.68	0	897.96	15.86	3,162.36	15.86
	7.5%	37-46-**60** (35%)	1,347.08	0	1,448.81	0	967.13	14.57	3,763.02	14.57
	10.0%	42-49-**60** (35%)	1,643.29	0	1,532.02	0	1,114.34	12.84	4,289.65	12.84
	12.5%	45-52-**60** (35%)	1,545.27	0	1,497.50	0	2,122.96	10.12	5,165.73	10.12
	15.0%	54-**60** (30%)	2,323.63	0	-	-	3,766.66	6.93	6,090.29	6.93

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted

Table 21. Financially optimal thinning and final harvest schedules for shortleaf pine plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	39-45-**60**[2] (35%)[3]	39-45-**60** (35%)	0%	39-45-**60** (35%)	0%	39-45-**60** (35%)	0%
	80	40-**60** (35%)	40-**60** (35%)	0%	40-**60** (35%)	0%	40-**60** (35%)	0%
	90	32-37-**60** (35%)	33-40-**60** (35%)	0%	33-40-**60** (35%)	0%	34-42-**60** (35%)	0%
5.00%	70	<39-45-**60**>[4](35%)	<45-**60**>(30%)	0%	45-**60** (30%)	0%	45-**60** (30%)	0%
	80	<40-**60**> (35%)	40-**60** (35%)	0%	40-**60** (35%)	0%	40-**60** (35%)	0%
	90	33-40-**60** (35%)	33-40-**60** (35%)	0%	34-42-**60** (35%)	0%	34-42-**60** (35%)	0%
7.50%	70	<41-**60**> (30%)	<41-**60**> (30%)	0%	<45-**60**>(30%)	0%	54-**60** (30%)	0%
	80	<36-42-**60**> (35%)	<40-**60**> (35%)	0%	40-**60** (35%)	0%	40-**60** (35%)	0%
	90	<34-39-**60**> (35%)	<34-39-**60**> (35%)	0%	34-42-**60** (35%)	0%	37-46-**60** (35%)	0%
10.00%	70	<41-**60**> (30%)	<41-**60**> (30%)	0%	<45-**60**> (30%)	0%	<54-**60**>(30%)	0%
	80	<36-42-**60**> (35%)	<40-**60**> (35%)	0%	<40-**60**> (30%)	0%	<40-**60**> (35%)	0%
	90	<35-40-**59**> (35%)	<35-40-**59**> (35%)	0%	<37-46-**60**> (35%)	2%	42-49-**60** (35%)	2%
12.50%	70	<39-**47**> (30%)	<41-**60**> (30%)	28%	<54-**60**> (30%)	28%	<54-**60**> (30%)	28%
	80	<36-41-**60**> (35%)	<36-42-**60**> (35%)	0%	<40-**60**> (35%)	0%	<40-**60**> (35%)	0%
	90	<33-38-**57**> (35%)	<35-40-**59**> (35%)	4%	<39-49-**59**> (35%)	4%	<45-52-**60**> (35%)	5%
15.00%	70	<39-**45**> (30%)	<41-**60**> (30%)	33%	<54-**60**> (30%)	33%	<54-**60**> (30%)	33%
	80	<36-41-**60**> (35%)	<36-42-**60**> (35%)	0%	<40-**60**> (35%)	0%	<46-**60**> (35%)	0%
	90	<33-38-**57**> (35%)	<35-40-**57**> (35%)	0%	<43-50-**58**> (35%)	2%	<54-**60**> (35%)	5%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning
[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for shortleaf pine plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	67.58	295.09	337%	909.36	1246%	1,205.13	1683%
	80	802.24	1,109.92	38%	1,940.66	142%	2,340.64	192%
	90	1,393.91	1,736.77	25%	2,671.42	92%	3,125.52	124%
5.00%	70	-254.84	-145.96		155.16		300.15	
	80	-114.36	27.21		409.44		593.48	
	90	9.23	173.23	1777%	620.08	6618%	835.37	8951%
7.50%	70	-285.48	-224.12		-57.66		22.61	
	80	-271.64	-192.05		24.81		129.22	
	90	-238.53	-142.33		119.91		248.26	
10.00%	70	-291.49	-254.24		-153.32		-104.26	
	80	-300.64	-251.93		-117.11		-52.20	
	90	-290.97	-228.92		-59.98		22.95	
12.50%	70	-292.23	-268.14		-202.67		-170.91	
	80	-303.76	-271.38		-182.04		-139.00	
	90	-300.58	-258.25		-142.83		-86.37	
15.00%	70	-291.85	-275.38		-230.52		-208.83	
	80	-301.66	-278.87		-216.53		-186.35	
	90	-300.43	-270.25		-187.84		-147.58	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

Southern- Shortleaf Pine - Timber Only Rotations (C = $0/ton)

Shortleaf Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 39 and 45 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $67.58 (Table 13), with a NPW of $52.59 per acre (Table 9). This means that $67.58 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $52.59 per acre for managing one rotation, or $67.58 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 4,043.28 cubic feet of pulpwood and 4.01 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 32.53 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Shortleaf Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 39 and 45 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$254.84 (Table 13), with a NPW of -$241.85 per acre (Table 9). This financially optimal rotation could

produce an estimated 4,043.28 cubic feet of pulpwood and 4.01 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 32.53 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning at stand age 41 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$285.48 (Table 13), with a NPW of -$282.01 per acre (Table 9). This financially optimal rotation could produce an estimated 5,333.21 cubic feet of pulpwood and 0.78 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 35.25 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 41 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$291.49 (Table 13), with a NPW of -$290.62 per acre (Table 9). This financially optimal rotation could produce an estimated 5,333.21 cubic feet of pulpwood and 0.78 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 35.25 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 39 (with 30 percent of basal area removed) and a final harvest at stand age 47 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$292.23 (Table 13), with a NPW of -$291.20 per acre (Table 9). This financially optimal rotation could produce an estimated 3,811.52 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 24.80 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 39 (with 30 percent of basal area removed) and a final harvest at stand age 45 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$291.85 (Table 13), with a NPW of -$291.38 per acre (Table 9). This financially optimal rotation could produce an estimated 3,553.93 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.16 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $802.24 (Table 13), with a NPW of $624.35 per acre (Table 9). This financially optimal rotation could produce an

estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 43.07 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$114.36 (Table 13), with a NPW of -$108.52 per acre (Table 9). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 43.07 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 36 and 42 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$271.64 (Table 13), with a NPW of -$268.34 per acre (Table 9). This financially optimal rotation could produce an estimated 3,525.28 cubic feet of pulpwood and 10.06 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 39.87 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 36 and 42 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$300.64 (Table 13), with a NPW of -$299.74 per acre (Table 9). This financially optimal rotation could produce an estimated 3,525.28 cubic feet of pulpwood and 10.06 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 39.87 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 36 and 41 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$303.76 (Table 13), with a NPW of -$303.53 per acre (Table 9). This financially optimal rotation could produce an estimated 3,567.49 cubic feet of pulpwood and 9.85 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 39.60 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 36 and 41 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$301.66 (Table 13), with a NPW of -$301.60 per acre (Table 9). This financially optimal rotation could

produce an estimated 3,567.49 cubic feet of pulpwood and 9.85 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 39.60 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 32 and 37 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $1,393.91 (Table 13), with a NPW of $1,084.82 per acre (Table 9). This financially optimal rotation could produce an estimated 2,585.10 cubic feet of pulpwood and 16.28 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 47.16 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 33 and 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $9.23 (Table 13), with a NPW of $8.76 per acre (Table 9). This financially optimal rotation could produce an estimated 2,925.33 cubic feet of pulpwood and 16.08 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 47.87 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 34 and 39 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$238.53 (Table 13), with a NPW of -$235.64 per acre (Table 9). This financially optimal rotation could produce an estimated 3,060.63 cubic feet of pulpwood and 15.90 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 47.64 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 35 and 40 (with 35 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$290.97 (Table 13), with a NPW of -$290.02 per acre (Table 9). This financially optimal rotation could produce an estimated 3,374.52 cubic feet of pulpwood and 14.49 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 46.64 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$300.58 (Table 13), with a NPW of -$300.25 per acre (Table 9). This financially optimal rotation could

produce an estimated 3,563.85 cubic feet of pulpwood and 11.63 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 44.48 net tons of carbon per acre during one rotation (Table 1).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$300.43 (Table 13), with a NPW of -$300.34 per acre (Table 9). This financially optimal rotation could produce an estimated 3,563.85 cubic feet of pulpwood and 11.63 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 44.48 net tons of carbon per acre during one rotation (Table 1).

<u>Southern- Shortleaf Pine - Timber Only Rotations (C = $10/ton)</u>

Shortleaf Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 39 and 45 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $295.09 (Table 14), with a NPW of $229.65 per acre (Table 10). This means that $295.09 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $229.65 per acre for managing one rotation, or $295.09 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 4,043.28 cubic feet of pulpwood and 4.01 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 32.53 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Shortleaf Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$145.96 (Table 14), with a NPW of -$138.52 per acre (Table 10). This financially optimal rotation could produce an estimated 5,398.89 cubic feet of pulpwood and 0.79 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 35.30 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning at stand age 41 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$224.12 (Table 14), with a NPW of -$221.40 per acre (Table 10). This financially optimal rotation could produce an estimated 5,333.21 cubic feet of pulpwood and 0.78 MBF of sawlogs per acre from the

thinning and final harvest (Table 18), and sequester 35.25 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 41 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$254.24 (Table 14), with a NPW of -$253.48 per acre (Table 10). This financially optimal rotation could produce an estimated 5,333.21 cubic feet of pulpwood and 0.78 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 35.25 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 41 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$268.14 (Table 14), with a NPW of -$267.94 per acre (Table 10). This financially optimal rotation could produce an estimated 5,333.21 cubic feet of pulpwood and 0.78 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 35.25 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 41 (with 30 percent of basal area

removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$275.38 (Table 14), with a NPW of -$275.33 per acre (Table 10). This financially optimal rotation could produce an estimated 5,333.21 cubic feet of pulpwood and 0.78 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 35.25 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $1,109.92 (Table 14), with a NPW of $863.80 per acre (Table 10). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 43.07 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $27.21 (Table 14), with a NPW of $25.82 per acre (Table 10). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the

thinning and final harvest (Table 18), and sequester 43.07 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$192.05 (Table 14), with a NPW of -$189.72 per acre (Table 10). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 43.07 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$251.93 (Table 14), with a NPW of -$251.18 per acre (Table 10). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 43.07 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 36 and 42 (with 35 percent of

basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$271.38 (Table 14), with a NPW of -$271.17 per acre (Table 10). This financially optimal rotation could produce an estimated 3,525.28 cubic feet of pulpwood and 10.06 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 39.87 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 36 and 42 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$278.87 (Table 14), with a NPW of -$278.82 per acre (Table 10). This financially optimal rotation could produce an estimated 3,525.28 cubic feet of pulpwood and 10.06 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 39.87 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 33 and 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $1,736.77 (Table 14), with a NPW of $1,351.66 per acre (Table 10). This financially optimal rotation could produce an estimated 2,925.33 cubic feet of pulpwood and 16.08 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 47.87 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 33 and 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $173.23 (Table 14), with a NPW of $164.39 per acre (Table 10). This financially optimal rotation could produce an estimated 2,925.33 cubic feet of pulpwood and 16.08 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 47.87 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 34 and 39 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$142.33 (Table 14), with a NPW of -$140.60 per acre (Table 10). This financially optimal rotation could produce an estimated 3,060.63 cubic feet of pulpwood and 15.90 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 47.64 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 35 and 40 (with 35 percent of

basal area removed) and a final harvest at stand age 59 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$228.92 (Table 14), with a NPW of -$228.17 per acre (Table 10). This financially optimal rotation could produce an estimated 3,374.52 cubic feet of pulpwood and 14.49 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 46.64 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 35 and 40 (with 35 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$258.25 (Table 14), with a NPW of -$258.03 per acre (Table 10). This financially optimal rotation could produce an estimated 3,374.52 cubic feet of pulpwood and 14.49 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 46.64 net tons of carbon per acre during one rotation (Table 2).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 35 and 40 (with 35 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$270.25 (Table 14), with a NPW of -$270.17 per acre (Table 10). This financially optimal rotation could produce an estimated 3,919.18 cubic feet of pulpwood and 11.22 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 44.75 net tons of carbon per acre during one rotation (Table 2).

Southern- Shortleaf Pine - Timber Only Rotations (C = $37/ton)

Shortleaf Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 39 and 45 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $909.36 (Table 15), with a NPW of $707.72 per acre (Table 11). This means that $909.36 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $707.72 per acre for managing one rotation, or $909.36 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 4,043.28 cubic feet of pulpwood and 4.01 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 32.53 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Shortleaf Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 45 (with 30 percent of basal area

removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $155.16 (Table 15), with a NPW of $147.25 per acre (Table 11). This financially optimal rotation could produce an estimated 5,398.89 cubic feet of pulpwood and 0.79 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 35.30 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning at stand age 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$57.66 (Table 15), with a NPW of -$56.96 per acre (Table 11). This financially optimal rotation could produce an estimated 5,398.89 cubic feet of pulpwood and 0.79 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 35.30 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$153.32 (Table 15), with a NPW of -$152.87 per acre (Table 11). This financially optimal rotation could produce an estimated 5,398.89 cubic feet of pulpwood and 0.79 MBF of sawlogs per acre from the

thinning and final harvest (Table 19), and sequester 35.30 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 54 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$202.67 (Table 15), with a NPW of -$202.52 per acre (Table 11). This financially optimal rotation could produce an estimated 5,484.34 cubic feet of pulpwood and 0.38 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 35.17 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 54 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$230.52 (Table 15), with a NPW of -$230.47 per acre (Table 11). This financially optimal rotation could produce an estimated 5,484.34 cubic feet of pulpwood and 0.38 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 35.17 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area

removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $1,940.66 (Table 15), with a NPW of $1,510.34 per acre (Table 11). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 43.07 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $409.44 (Table 15), with a NPW of $388.57 per acre (Table 11). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 43.07 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $24.81 (Table 15), with a NPW of $24.51 per acre (Table 11). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the

thinning and final harvest (Table 19), and sequester 43.07 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$117.11 (Table 15), with a NPW of -$116.76 per acre (Table 11). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 43.07 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$182.04 (Table 15), with a NPW of -$181.90 per acre (Table 11). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 43.07 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area

removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$216.53 (Table 15), with a NPW of -$216.49 per acre (Table 11). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 43.07 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 33 and 40 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $2,671.42 (Table 15), with a NPW of $2,079.06 per acre (Table 11). This financially optimal rotation could produce an estimated 2,925.33 cubic feet of pulpwood and 16.08 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 47.87 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 34 and 42 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $620.08 (Table 15), with a NPW of $588.47 per acre (Table 11). This financially optimal rotation could produce an estimated 3,162.36 cubic feet of pulpwood and 15.86 MBF of sawlogs per

acre from the thinning and final harvest (Table 19), and sequester 48.28 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 34 and 42 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $119.91 (Table 15), with a NPW of $118.46 per acre (Table 11). This financially optimal rotation could produce an estimated 3,162.36 cubic feet of pulpwood and 15.86 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 48.28 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 37 and 46 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$59.98 (Table 15), with a NPW of -$59.80 per acre (Table 11). This financially optimal rotation could produce an estimated 3,763.02 cubic feet of pulpwood and 14.57 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 48.97 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 39 and 49 (with 35 percent of

basal area removed) and a final harvest at stand age 59 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$142.83 (Table 15), with a NPW of -$142.71 per acre (Table 11). This financially optimal rotation could produce an estimated 4,234.15 cubic feet of pulpwood and 12.56 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 48.68 net tons of carbon per acre during one rotation (Table 3).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 43 and 50 (with 35 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$187.84 (Table 15), with a NPW of -$187.79 per acre (Table 11). This financially optimal rotation could produce an estimated 4,816.82 cubic feet of pulpwood and 9.85 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 48.03 net tons of carbon per acre during one rotation (Table 3).

<u>Southern- Shortleaf Pine - Timber Only Rotations (C = $50/ton)</u>

Shortleaf Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 39 and 45 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $1,205.13 (Table 16), with a NPW of $937.90 per acre (Table 12). This means that $1,205.13 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $937.90 per acre for managing one rotation, or $1,205.13 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 4,043.28 cubic feet of pulpwood and 4.01 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 32.53 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Shortleaf Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $300.15 (Table 16), with a NPW of $284.85 per acre (Table 12). This financially optimal rotation could produce an estimated 5,398.89 cubic feet of pulpwood and 0.79 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 35.30 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning at stand age 54 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal

management regime will generate the maximum SEV of $22.61 (Table 16), with a NPW of $22.33 per acre (Table 12). This financially optimal rotation could produce an estimated 5,484.34 cubic feet of pulpwood and 0.38 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 35.17 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 54 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$104.26 (Table 16), with a NPW of -$103.95 per acre (Table 12). This financially optimal rotation could produce an estimated 5,484.34 cubic feet of pulpwood and 0.38 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 35.17 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two a thinning at stand age 54 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$170.91 (Table 16), with a NPW of -$170.78 per acre (Table 12). This financially optimal rotation could produce an estimated 5,484.34 cubic feet of pulpwood and 0.38 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 35.17 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 54 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$208.83 (Table 16), with a NPW of -$208.78 per acre (Table 12). This financially optimal rotation could produce an estimated 5,484.34 cubic feet of pulpwood and 0.38 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 35.17 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $2,340.64 (Table 16), with a NPW of $1,821.63 per acre (Table 12). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 43.07 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $593.48 (Table 16), with a NPW of $563.22 per acre (Table 12). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 43.07 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $129.22 (Table 16), with a NPW of $127.65 per acre (Table 12). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 43.07 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$52.20 (Table 16), with a NPW of -$52.04 per acre (Table 12). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 43.07 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$139.00 (Table 16), with a NPW of -$138.89 per acre (Table 12). This financially optimal rotation could produce an estimated 5,250.55 cubic feet of pulpwood and 5.66 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 43.07 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 46 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$186.35 (Table 16), with a NPW of -$186.31 per acre (Table 12). This financially optimal rotation could produce an estimated 5,592.45 cubic feet of pulpwood and 4.39 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 43.18 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 34 and 42 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $3,125.52 (Table 16), with a NPW of $2,432.46 per acre (Table 12). This financially optimal rotation could

produce an estimated 3,162.36 cubic feet of pulpwood and 15.86 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 48.28 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 34 and 42 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $835.37 (Table 16), with a NPW of $792.78 per acre (Table 12). This financially optimal rotation could produce an estimated 3,162.36 cubic feet of pulpwood and 15.86 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 48.28 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 37 and 46 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $248.26 (Table 16), with a NPW of $245.25 per acre (Table 12). This financially optimal rotation could produce an estimated 3,763.02 cubic feet of pulpwood and 14.57 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 48.97 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 42 and 49 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $22.95 (Table 16), with a NPW of $22.88 per acre (Table 12). This financially optimal rotation could produce an estimated 4,289.65 cubic feet of pulpwood and 12.84 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 49.57 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 45 and 52 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$86.37 (Table 16), with a NPW of -$86.30 per acre (Table 12). This financially optimal rotation could produce an estimated 5,165.73 cubic feet of pulpwood and 10.12 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 51.00 net tons of carbon per acre during one rotation (Table 4).

Shortleaf Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 54 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$147.58 (Table 16), with a NPW of -$147.55 per acre (Table 12). This financially optimal rotation could produce an

estimated 6,090.29 cubic feet of pulpwood and 6.93 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 52.01 net tons of carbon per acre during one rotation (Table 4).

Slash pine (*Pinus elliottii*)

Biological Information

Slash pine is one of the most commonly planted timber species in North America. The native range of slash pine extends from southern South Carolina to central Florida and west to eastern Louisiana. It has been successfully established as far west as eastern Texas, and as far north as Tennessee (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/elliottii.htm. June 16, 2006) (Fig. 1).

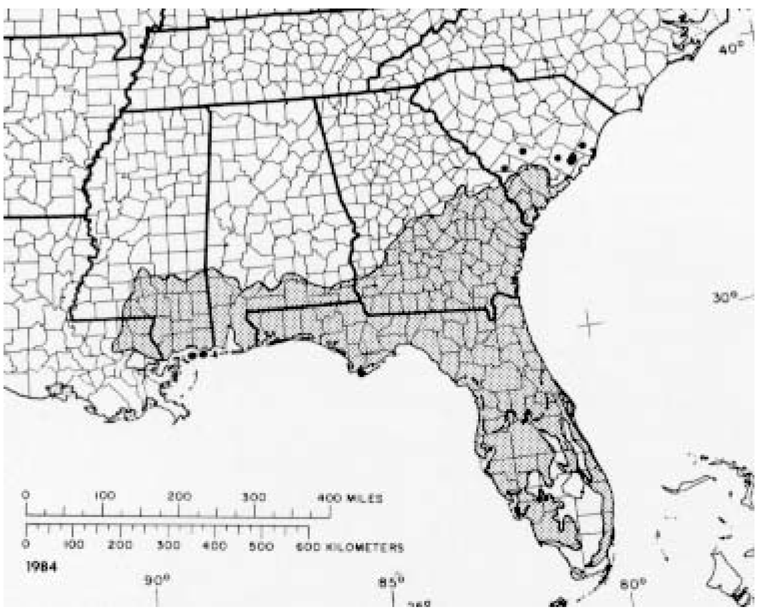

Fig. 1. The native range of slash pine (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/elliottii.htm. June 16, 2006)

In natural forest conditions site indices average between 75 and 90 feet base age 50. Slash pine produces rapid volume growth at young ages and is highly adaptable to short intensive rotations. Regardless of stand basal area, approximately three quarters of the 50-year merchantable yield is produced by age 30 (USDA Forest Service.

http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/elliottii.htm. June 16, 2006).

Slash pine is classified as intolerant of shade, and does not survive or grow well when competition is severe. Increased survival and growth on intensively managed sites is largely attributed to competition control. Even aged management is the recommended system for slash pine, either through planting or the seed-tree and shelterwood systems (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/elliottii.htm. June 16, 2006).

Slash pine is frequently infected by the fungus *Cronartium quercuum* f. sp. *Fusiforme*, commonly referred to as fusiform rust. The fungus causes cankers to develop on the bole and either kill or reduce the timber value of the logs. Site preparation treatments such as vegetation control and fertilization increase a trees susceptibility to the disease (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/elliottii.htm. June 16, 2006).

Slash pine is used for plywood, lumber, pulpwood, and other structural materials. It is also worked for naval stores, and has supplied a large portion of the resin and turpentine used since colonial times. The seeds are eaten by a variety of small mammals and birds (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/elliottii.htm. June 16, 2006).

Economic Background

Stainbackn and Alavalapati (2005) studied the effects of carbon markets on the optimal management of slash pine plantations. The objective was to evaluate internalization of carbon sequestration benefits on financially optimal management of slash pine stands. Eight combinations of four management options were considered, chop and burn, bedding, herbicide, and fertilization. Price per ton for carbon sequestered was $0, $40, or $200. Their results showed that chop and burn alone resulted in the longest rotation age for all carbon prices, while herbicide caused the greatest reductions in rotation length followed by fertilizer and, finally, bedding. The management options that included all techniques resulted in the greatest reduction in optimal rotation age. In conclusion they found that when carbon benefits are not included it is optimal to use bedding and herbicide but not fertilizer. When the carbon price equals $40 per metric ton it becomes profitable to use fertilizer.

Gong and Yin (2004) incorporated market uncertainty into the assessment of the economic performance of investments in slash pine plantations. Site preparation costs were set at $88/ac, seedling and planting costs at $64/ac (600 trees/ac), bedding at $48/ac, herbicide at $42/ac, constant maintenance cost of $1.2/ac/quarter, and a quarterly discount rate of 1.5%. Pulpwood stumpage ranged from $17 to $49 per cord, and sawtimber stumpage prices ranged from $52 to $128 per cord. Multiple iterations were run and the large number of NPV "observations" was used to construct the probability distribution of the NPV. The results indicated that both sawtimber and pulpwood prices are stochastic and that a high enough price for one product to motivate harvesting depends on the price of the other product. In all six management regimes investigated, the reservation price of sawtimber at each age decreased when the observed pulpwood price increased, but also decreased as stand age increased.

Bridgwater and Smith (2002) reported estimated losses in product values on surviving stems of slash pine due to fusiform rust. Four plantations with varying levels of fusiform infection (low, intermediate, and high) were chosen for the study. Observations were made at ages 1-16 and age 25 to locate galls and determine mortality. A computer algorithm was developed to merchandise the trees by 2 ft increments beginning at a stump height of 0.3ft. Each segment was checked for the presence of a gall, and if one occurred it was assigned to rust volume. Initial planting density was 750 trees per acre, but combined mortality resulted in 136 to 298 trees per acre at age 25. Stands with higher rust infection rates resulted in reduced frequency of butt logs, causing a dramatic reduction in stand value. Stand value declined by 0.26% for each 1% increase in the percentage of stems infected.

Cubbage et al. (2000) evaluated economic returns from past fusiform rust resistance programs. A model was designed to simulate the establishment of new plantations, growth to rotation age, harvesting, merchandising, and valuation. Two scenarios were included to reflect with and without the use of genetically resistant seedlings. For both scenarios no thinnings were specified and initial planting density was 700 seedlings/acre. Survivorship varied by site quality: 75% for low quality, 80% for medium, and 85% for high. Site indices ranged from 50 to 70 base age 25. In the absence of rust simulations showed markedly increased yields for higher site qualities and economically optimal rotations were always lower than 35 years. Infection levels of 10 to 20 percent sometimes resulted increased value when compared to the no rust case.

This may have been caused by overcompensation for mortality at planting. The marginal benefits of reduced infection rates were higher on short rotation stands regardless of site index. The benefit cost ratios were always greater than one, and research costs could double, and in some cases increase by a factor of 10, and net benefits would remain positive. This means that greater production of resistant seedlings or development of new technologies could yield substantial additional benefits to the industry.

Brawner et al. (1999) evaluated projected rotation age gains in volume production and soil expectation value by planting fusiform rust resistant stock. A pulpwood price of \$13.7/ cubic meter was used; chip-and-saw, \$27.5/ cubic meter; and sawtimber, \$35.3/ cubic meter. One or all of the following costs could have been included: \$12.4/ha per year management cost, \$371/ha for site prep., 321/ha for fertilization and herbicide, and \$173/ha for third-year oak control. SEV's were calculated using four real discount rates (4, 6, 8, and 10%). The optimal economic rotation age was within the range of 20-25 years for all scenarios. Two merchandising regimes were considered, complete cull and full utilization. In complete cull all trees with stem galls were placed in the pulpwood class. In complete utilization no trees were culled to the pulpwood class. Results indicated that across all cultural treatments resistant stock produced 16.1% more projected volume at 20 years and 18.8% more at 25 years than unimproved stock. Bare land planted in resistant slash pine seedlings would be worth between 40.2 and 89.8% more than bare land established with susceptible stock. Resistance was found to significantly increase projected volume production and SEV over susceptible slash pine.

Baldwin and Busby (1992) compared the predicted mensurational and economic performance of thinned loblolly and slash pine plantations in Louisiana. Three possible management scenarios were utilized in which zero, one, or two thinnings were possible. Site indices of 50, 60, and 70 base age 25 for loblolly pine were used; these site indices corresponded to site indexes of 61, 67, and 73 for slash pine. Site preparation costs were assumed to be constant and were set at $87/acre. Planting costs were $38/acre plus $0.03/tree (681 trees/acre); marking and cruising were $13.07 and $2.02 respectively. All other costs were assumed to equal $3/acre/year. Costs were expected to increase at the same rate s inflation. Stumpage prices were set to $147.07/MBF for sawtimber, and $20.96/cord for pulpwood. Sawtimber prices were expected to show a real growth rate of 1.5% per year. Pulpwood prices were kept constant throughout the analysis. The results indicate that dominant height growth was almost always greater for slash than for loblolly regardless of site index. However, only when thinning was heavy did slash outperform loblolly in basal area and diameter growth. On low and medium-quality sites slash pine produced higher economic values than loblolly, but the reverse was true on high-quality sites.

Keister (1972) determined that thinning in slash pine plantations produce little increase in volume after age 40. This determination was made based on results of a thinning study established in 1937 in a 13-year-old plantation. The results were subjected to an economic analysis to determine whether a 29, 40, or 47-year rotation was most desirable. Comparisons were made based upon land expectation values. Pulpwood was valued from $4.5 to $15 per cord, and sawtimber from $35 to $70 per MBF. Planting costs of $30, $40, and $50 per acre were used. Thirteen interest rates from 4 to 10 percent in 0.5 percent increments were used. As expected low pulpwood prices favored the 40-year rotation, while high pulpwood prices favored the 29-year rotation. Under no circumstances was the 47-year rotation more economically desirable than the other two rotations.

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Species Slash pine Region South

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 7-in. inside bark top diameter for trees with a minimum of 10 in diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 9-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 15 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 25, 30 and 35% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.194648829 and 0.668896321, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Taras and Phillips (1978) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$\text{Log}_{10}Y = -1.16061+1.03527\text{Log}_{10}(D^2Th)$$

where:

Y = aboveground dry-weight with leaves (lbs.)

D = diameter at breast height (in.)

Th = total tree height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.6% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $296/mbf (Scribner) (Timber Mart South, Inc 2000-2005) and pulpwood price was assumed to be $18.43/cord (Timber Mart South, Inc 2000-2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of slash pine plantations in the South.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$80.28	Only once	Year 0	
Seedlings[a] (600 seedlings/ac)	$25.81	Only Once	Year 0	
Burning[a]	$21.24	Every 5 years	Year 10	Final Harvest
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al (2005).

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Table 1. Total tons of carbon sequestered per acre for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	43.74	42.18	36.69	35.29	33.84	33.84
80	51.72	47.59	41.07	40.62	37.24	37.24
90	60.79	51.68	45.89	41.83	40.79	40.79

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	43.74	42.18	36.69	35.29	35.29	33.84
80	51.72	47.59	44.53	40.62	38.42	37.24
90	60.79	52.02	49.48	41.83	46.68	40.79

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	43.74	43.59	41.55	38.12	39.81	35.92
80	53.15	47.59	45.72	44.68	43.55	42.60
90	63.41	52.02	53.74	50.48	46.78	46.78

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	43.74	44.90	43.03	42.16	39.77	39.77
80	54.16	52.81	50.09	47.62	46.24	44.89
90	63.79	59.23	53.86	50.48	50.48	50.48

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	33-40-**59**[2] (30%)[3]	33-38-**57** (30%)	<32-37-**51**>[4](35%)	<32-37-**49**>(35%)	<32-37-**47**>(35%)	<32-37-**47**>(35%)
80	31-**60** (35%)	31-36-**52** (30%)	<28-34-**47**>(35%)	<30-35-**46**>(35%)	<28-33-**43**>(35%)	<28-33-**43**>(35%)
90	27-**60** (35%)	27-32-**48** (30%)	<25-35-**44**>(35%)	<25-30-**41**>(35%)	<25-30-**40**>(35%)	<25-30-**40**>(35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	33-40-**59**[2] (30%)[3]	33-38-**57** (30%)	<32-37-**51**>[4](35%)	<32-37-**49**>(35%)	<32-37-**49**>(35%)	<32-37-**47**>(35%)
80	31-**60** (35%)	31-36-**52** (30%)	<30-37-**49**>(30%)	<30-35-**46**>(35%)	<29-34-**44**>(35%)	<28-33-**43**>(35%)
90	27-**60** (35%)	28-33-**48** (30%)	27-34-**46** (30%)	<25-30-**41**>(35%)	<28-33-**43**>(25%)	<25-30-**40**>(35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	33-40-**59**[2] (30%)[3]	40-45-**58** (25%)	40-46-**55** (25%)	35-40-**51**(30%)	<45-**52**>[4](35%)	<40-**47**> (35%)
80	36-**60** (25%)	31-36-**52** (30%)	33-38-**50** (30%)	40-**48** (25%)	<39-**47**> (25%)	<39-**46**> (25%)
90	39-**60** (30%)	28-33-**48** (30%)	34-39-**49** (25%)	40-**45** (30%)	37-**42** (35%)	<37-**42**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	33-40-**59**[2] (30%)[3]	43-48-**59** (25%)	42-51-**57** (25%)	49-55 (35%)	<46-**52**>[4] (25%)	<46-**52**> (25%)
80	40-**60** (25%)	42-**58** (25%)	39-44-**54** (25%)	43-**51** (30%)	44-**49** (30%)	<43-**48**> (25%)
90	38-**60** (25%)	39-**55** (30%)	34-41-**49** (25%)	40-**45** (30%)	40-**45** (30%)	40-**45** (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,422.03	$103.97	-$193.71	-$271.17	-$292.51	-$297.23
80	$1,867.00	$252.87	-$135.66	-$247.48	-$281.41	-$292.08
90	$2,323.50	$409.48	-$68.09	-$212.14	-$264.91	-$284.17

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,695.36	$271.93	-$87.85	-$197.07	-$238.41	-$256.03
80	$2,209.20	$458.16	-$3.10	-$151.69	-$210.79	-$237.46
90	$2,732.50	$649.12	$95.67	-$96.88	-$101.83	-$214.58

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$2,433.36	$729.29	$207.12	$6.27	-$89.70	-$143.39
80	$3,146.50	$1,012.44	$369.90	$110.52	-$15.03	-$86.94
90	$3,874.00	$1,299.28	$551.09	$228.58	$70.07	-$21.54

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$2,788.69	$962.95	$355.72	$108.53	-$16.31	-$88.63
80	$3,609.20	$1,311.15	$558.74	$243.73	$81.89	-$13.27
90	$4,434.60	$1,672.77	$779.15	$393.28	$193.01	$73.03

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,840.31	$110.50	-$198.33	-$273.50	-$293.54	-$297.60
80	$2,399.00	$273.47	-$140.01	-$250.32	-$283.00	-$292.71
90	$2,985.50	$450.75	-$70.82	-$216.09	-$267.04	-$285.10

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$2,194.03	$288.98	-$89.95	-$198.77	-$239.07	-$256.34
80	$2,838.60	$495.48	-$3.18	-$153.43	-$211.84	-$237.97
90	$3,511.10	$714.55	$98.98	-$98.68	-$103.39	-$215.28

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$3,149.09	$772.72	$210.79	$6.32	-$89.87	-$143.57
80	$4,042.90	$1,094.92	$379.39	$111.56	-$15.09	-$87.06
90	$4,977.80	$1,430.24	$566.32	$231.47	$70.52	-$21.59

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for slash pine plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$3,608.94	$1,017.42	$361.16	$109.06	-$16.34	-$88.68
80	$4,637.60	$1,389.24	$569.41	$245.45	$82.12	-$13.29
90	$5,698.10	$1,789.20	$800.68	$398.24	$193.87	$73.15

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for slash pine plantations by soil productivity and real alternative rates of return in the southern United States). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	33-40-**59**[3] (30%)[4]	561.46	0	831.68	0	391.56	20.05	1,784.70	20.05
	5.0%	33-38-**57** (30%)	561.46	0	759.83	0	415.84	18.83	1,737.13	18.83
	7.5%	32-37-**51** (35%)	586.25	0	811.77	0	420.03	13.82	1,818.05	13.82
	10.0%	32-37-**49** (35%)	586.25	0	811.77	0	546.32	11.94	1,944.34	11.94
	12.5%	32-37-**47** (35%)	586.25	0	811.77	0	770.47	9.61	2,168.49	9.61
	15.0%	32-37-**47** (35%)	586.25	0	811.77	0	770.47	9.61	2,168.49	9.61
80	2.5%	31-**60** (35%)	818.48	0	-[5]	-	730.24	25.82	1,548.72	25.82
	5.0%	31-36-**52** (30%)	666.43	0	890.44	0	478.02	19.94	2,034.89	19.94
	7.5%	28-34-**47** (35%)	588.68	0	922.19	0	471.46	14.91	1,982.33	14.91
	10.0%	30-35-**46** (35%)	723.83	0	952.63	0	483.42	13.82	2,159.88	13.82
	12.5%	28-33-**43** (35%)	588.68	0	869.76	0	914.68	10.09	2,373.12	10.09
	15.0%	28-33-**43** (35%)	588.68	0	869.76	0	914.68	10.09	2,373.12	10.09
90	2.5%	27-**60** (35%)	776.75	0	-	-	725.93	31.06	1,502.68	31.06
	5.0%	27-32-**48** (30%)	624.44	0	921.31	0	526.47	21.02	2,072.22	21.02
	7.5%	25-32-**44** (35%)	552.63	0	1,051.57	0	497.87	16.46	2,102.07	16.46
	10.0%	25-30-**41** (35%)	552.63	0	934.41	0	671.21	13.26	2,158.25	13.26
	12.5%	25-30-**40** (35%)	552.63	0	934.41	0	808.85	11.86	2,295.89	11.86
	15.0%	25-30-**40** (35%)	552.63	0	934.41	0	808.85	11.86	2,295.89	11.86

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indiates no operation conducted.

Table 18. Volume removed from the financially optimal schedules for slash pine plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	33-40-**59**[3] (30%)[4]	561.46	0	831.68	0	391.56	20.05	1,784.70	20.05
	5.0%	33-38-**57** (30%)	561.46	0	759.83	0	415.81	18.83	1,737.10	18.83
	7.5%	32-37-**51** (35%)	586.25	0	811.77	0	420.03	13.82	1,818.05	13.82
	10.0%	32-37-**49** (35%)	586.25	0	811.77	0	546.32	11.94	1,944.34	11.94
	12.5%	32-37-**49** (35%)	586.25	0	811.77	0	546.32	11.94	1,944.34	11.94
	15.0%	32-37-**47** (35%)	586.25	0	811.77	0	770.47	9.61	2,168.49	9.61
80	2.5%	31-**60** (35%)	818.48	0	-[5]	-	730.24	25.82	1,548.72	25.82
	5.0%	31-36-**52** (30%)	666.43	0	890.44	0	478.02	19.94	2,034.89	19.94
	7.5%	30-37-**49** (30%)	580.41	0	931.02	0	607.05	16.88	2,118.48	16.88
	10.0%	30-35-**46** (35%)	723.83	0	952.63	0	483.42	13.82	2,159.88	13.82
	12.5%	29-34-**44** (35%)	642.47	0	912.03	0	755.83	11.33	2,310.33	11.33
	15.0%	28-33-**43** (35%)	588.68	0	869.76	0	914.68	10.09	2,373.12	10.09
90	2.5%	27-**60** (35%)	776.75	0	-	-	725.93	31.06	1,502.68	31.06
	5.0%	28-33-**48** (30%)	768.50	0	958.61	0	534.96	20.88	2,262.07	20.88
	7.5%	27-34-**46** (30%)	624.44	0	1,005.31	0	538.52	18.90	2,168.27	18.90
	10.0%	25-30-**41** (35%)	522.63	0	934.41	0	671.21	13.26	2,128.25	13.26
	12.5%	28-33-**43** (25%)	608.32	0	815.30	0	1,349.19	14.41	2,772.81	14.41
	15.0%	25-30-**40** (35%)	552.63	0	934.41	0	808.85	11.86	2,295.89	11.86

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indiates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for slash pine plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	33-40-**59**[3] (30%)[4]	561.46	0	831.68	0	391.56	20.05	1,784.70	20.05
	5.0%	40-45-**58** (25%)	789.54	0	814.85	0	498.89	18.72	2,103.28	18.72
	7.5%	40-46-**55** (25%)	789.54	0	838.25	0	648.66	16.05	2,276.45	16.05
	10.0%	35-40-**51** (30%)	676.09	0	822.19	0	664.81	13.34	2,163.09	13.34
	12.5%	45-**52** (35%)	1,382.28	0	-[5]	-	1,338.06	12.29	2,720.34	12.29
	15.0%	40-**47** (35%)	1,147.17	0	-	-	1,746.29	8.33	2,893.46	8.33
80	2.5%	36-**60** (25%)	841.42	0	-	-	1,073.30	25.43	1,914.72	25.43
	5.0%	31-36-**52** (30%)	666.43	0	890.44	0	478.02	19.94	2,034.89	19.94
	7.5%	33-38-**50** (30%)	797.69	0	953.31	0	469.74	17.60	2,220.74	17.60
	10.0%	40-**48** (25%)	1,025.17	0	-	-	1,974.69	13.30	2,999.86	13.30
	12.5%	39-**47** (25%)	986.92	0	-	-	2,003.20	12.53	2,990.12	12.53
	15.0%	39-**46** (25%)	986.92	0	-	-	2,106.53	11.35	3,093.45	11.35
90	2.5%	39-**60** (30%)	1,479.60	0	-	-	642.23	30.43	2,121.83	30.43
	5.0%	28-33-**48** (30%)	768.50	0	958.61	0	534.96	20.88	2,262.07	20.88
	7.5%	34-39-**49** (25%)	991.97	0	1,012.26	0	579.17	20.87	2,583.40	20.87
	10.0%	40-**45** (30%)	1,532.05	0	-	-	1,777.17	14.80	3,309.22	14.80
	12.5%	37-**42** (35%)	1,621.36	0	-	-	1,762.08	11.96	3,383.44	11.96
	15.0%	37-**42** (35%)	1,621.36	0	-	-	1,762.08	11.96	3,383.44	11.96

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indiates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for slash pine plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	33-40-**59**[3] (30%)[4]	561.46	0	831.68	0	391.56	20.05	1,784.70	20.05
	5.0%	43-48-**59** (25%)	896.35	0	885.62	0	444.23	19.11	2,226.20	19.11
	7.5%	42-51-**57** (25%)	863.39	0	951.24	0	452.75	17.36	2,267.38	17.36
	10.0%	49-**55** (35%)	1,555.28	0	-[5]	-	1,076.94	14.55	2,632.22	14.55
	12.5%	46-**52** (25%)	991.05	0	-	-	1,786.80	11.93	2,777.85	11.93
	15.0%	46-**52** (25%)	991.05	0	-	-	1,786.80	11.93	2,777.85	11.93
80	2.5%	40-**60** (25%)	1,025.2	0	-	-	1,106.60	25.05	2,131.80	25.05
	5.0%	42-**58** (25%)	1,101.21	0	-	-	1,181.57	23.16	2,282.78	23.16
	7.5%	39-44-**54** (25%)	986.92	0	982.37	0	487.91	20.19	2,457.20	20.19
	10.0%	43-**51** (30%)	1,384.60	0	-	-	1,472.81	16.21	2,857.41	16.21
	12.5%	44-**49** (30%)	1,426.56	0	-	-	1,691.41	13.83	3,117.97	13.83
	15.0%	43-**48** (25%)	1,139.43	0	-	-	1,984.43	12.83	3,123.86	12.83
90	2.5%	38-**60** (25%)	1,172.6	0	-	-	991.82	30.35	2,164.42	30.35
	5.0%	39-**55** (30%)	1,479.56	0	-	-	906.55	25.82	2,386.11	25.82
	7.5%	34-41-**49** (25%)	991.97	0	1,079.60	0	542.98	20.80	2,614.55	20.80
	10.0%	40-**45** (30%)	1,532.05	0	-	-	1,777.17	14.80	3,309.22	14.80
	12.5%	40-**45** (30%)	1,532.05	0	-	-	1,777.17	14.80	3,309.22	14.80
	15.0%	40-**45** (30%)	1,532.05	0	-	-	1,777.17	14.80	3,309.22	14.80

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted

Table 21. Financially optimal thinning and final harvest schedules for slash pine plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	33-40-**59**[2] (30%)[3]	33-40-**59** (30%)	0%	33-40-**59** (30%)	0%	33-40-**59** (30%)	0%
	80	31-**60** (35%)	31-**60** (35%)	0%	36-**60** (25%)	0%	40-**60** (25%)	0%
	90	27-**60** (35%)	27-**60** (35%)	0%	39-**60** (30%)	0%	38-**60** (25%)	0%
5.00%	70	33-38-**57** (30%)	33-38-**57** (30%)	0%	40-45-**58** (25%)	2%	43-48-**59** (25%)	4%
	80	31-36-**52** (30%)	31-36-**52** (30%)	0%	31-36-**52** (30%)	0%	42-**58** (25%)	12%
	90	27-32-**48** (30%)	28-33-**48** (30%)	0%	28-33-**48** (30%)	0%	39-**55** (30%)	15%
7.50%	70	<32-37-**51**>[4] (35%)	<32-37-**51**> (35%)	0%	40-46-**55** (25%)	8%	42-51-**57** (25%)	12%
	80	<28-34-**47**> (35%)	<30-37-**49**> (30%)	4%	33-38-**50** (30%)	6%	39-44-**54** (25%)	15%
	90	<25-35-**44**> (35%)	27-34-**46** (30%)	5%	34-39-**49** (25%)	11%	34-41-**49** (25%)	11%
10.00%	70	<32-37-**49**> (35%)	<32-37-**49**> (35%)	0%	35-40-**51**(30%)	4%	49-**55** (35%)	12%
	80	<30-35-**46**> (35%)	<30-35-**46**> (35%)	0%	40-**48** (25%)	4%	43-**51** (30%)	11%
	90	<25-30-**41**> (35%)	<25-30-**41**> (35%)	0%	40-**45** (30%)	10%	40-**45** (30%)	10%
12.50%	70	<32-37-**47**> (35%)	<32-37-**49**> (35%)	4%	<45-**52**> (35%)	11%	<46-**52**> (25%)	11%
	80	<28-33-**43**> (35%)	<29-34-**44**> (35%)	2%	<39-**47**> (25%)	9%	44-**49** (30%)	14%
	90	<25-30-**40**> (35%)	<28-33-**43**> (25%)	8%	37-**42** (35%)	5%	40-**45** (30%)	13%
15.00%	70	<32-37-**47**> (35%)	<32-37-**47**> (35%)	0%	<40-**47**> (35%)	0%	<46-**52**> (25%)	11%
	80	<28-33-**43**> (35%)	<28-33-**43**> (35%)	0%	<39-**46**> (25%)	7%	<43-**48**> (25%)	12%
	90	<25-30-**40**> (35%)	<25-30-**40**> (35%)	0%	<37-**42**> (35%)	5%	40-**45** (30%)	13%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning
[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for slash pine plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	1,840.31	2,194.03	19%	3,149.09	71%	3,608.94	96%
	80	2,399.00	2,838.60	18%	4,042.90	69%	4,637.60	93%
	90	2,985.50	3,511.10	18%	4,977.80	67%	5,698.10	91%
5.00%	70	110.50	288.98	162%	772.72	599%	1,017.42	821%
	80	273.47	495.48	81%	1,094.92	300%	1,389.24	408%
	90	450.75	714.55	59%	1,430.24	217%	1,789.20	297%
7.50%	70	-198.33	-89.95		210.79		361.16	
	80	-140.01	-3.18		379.39		569.41	
	90	-70.82	98.98		566.32		800.68	
10.00%	70	-273.50	-198.77		6.32		109.06	
	80	-250.32	-153.43		111.56		245.45	
	90	-216.09	-98.68		231.47		398.24	
12.50%	70	-293.54	-239.07		-89.87		-16.34	
	80	-283.00	-211.84		-15.09		82.12	
	90	-267.04	-103.39		70.52		193.87	
15.00%	70	-297.60	-256.34		-143.57		-88.68	
	80	-292.71	-237.97		-87.06		-13.29	
	90	-285.10	-215.28		-21.59		73.15	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>Southern- Slash Pine - Timber Only Rotations (C = $0/ton)</u>

Slash Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 33 and 40 (with 30 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $1,840.31 (Table 13), with a NPW of $1,422.03 per acre (Table 9). This means that $1,840.31 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,422.03 per acre for managing one rotation, or $1,840.31 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 1,784.70 cubic feet of pulpwood and 20.05 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 43.74 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Slash Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $110.50 (Table 13), with a NPW of $103.97 per acre (Table 9). This financially optimal rotation could

produce an estimated 1,737.13 cubic feet of pulpwood and 18.83 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 42.18 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 32 and 37 (with 35 percent of basal area removed) and a final harvest at stand age 51 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$198.33 (Table 13), with a NPW of -$193.71 per acre (Table 9). This financially optimal rotation could produce an estimated 1,818.05 cubic feet of pulpwood and 13.82 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 36.69 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 32 and 37 (with 35 percent of basal area removed) and a final harvest at stand age 49 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$273.50 (Table 13), with a NPW of -$271.17 per acre (Table 9). This financially optimal rotation could produce an estimated 1,944.34 cubic feet of pulpwood and 11.94 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 35.29 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 32 and 37 (with 35 percent of basal area removed) and a final harvest at stand age 47 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$293.54 (Table 13), with a NPW of -$292.51 per acre (Table 9). This financially optimal rotation could produce an estimated 2,168.49 cubic feet of pulpwood and 9.61 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 33.84 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 32 and 37 (with 35 percent of basal area removed) and a final harvest at stand age 47 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$297.60 (Table 13), with a NPW of -$297.23 per acre (Table 9). This financially optimal rotation could produce an estimated 2,168.49 cubic feet of pulpwood and 9.61 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 33.84 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 31 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $2,399.00 (Table 13), with a NPW of $1,867.00 per acre (Table 9). This financially optimal rotation could produce an

estimated 1,548.72 cubic feet of pulpwood and 25.82 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 51.72 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 31 and 36 (with 30 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $273.47 (Table 13), with a NPW of $252.87 per acre (Table 9). This financially optimal rotation could produce an estimated 2,034.89 cubic feet of pulpwood and 19.94 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 47.59 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 28 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 47 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$140.01 (Table 13), with a NPW of -$135.66 per acre (Table 9). This financially optimal rotation could produce an estimated 1,982.33 cubic feet of pulpwood and 14.91 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 41.07 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with 35 percent of basal area removed) and a final harvest at stand age 46 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$250.32 (Table 13), with a NPW of -$247.48 per acre (Table 9). This financially optimal rotation could produce an estimated 2,159.88 cubic feet of pulpwood and 13.82 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 40.62 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 28 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 43 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$283.00 (Table 13), with a NPW of -$281.41 per acre (Table 9). This financially optimal rotation could produce an estimated 2,373.12 cubic feet of pulpwood and 10.09 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 37.24 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 28 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 43 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$292.71 (Table 13), with a NPW of -$292.08 per acre (Table 9). This financially optimal rotation could

produce an estimated 2,373.12 cubic feet of pulpwood and 10.09 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 37.24 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 27 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $2,985.50 (Table 13), with a NPW of $2,323.50 per acre (Table 9). This financially optimal rotation could produce an estimated 1,502.68 cubic feet of pulpwood and 31.06 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 60.79 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 27 and 32 (with 30 percent of basal area removed) and a final harvest at stand age 48 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $450.75 (Table 13), with a NPW of $409.48 per acre (Table 9). This financially optimal rotation could produce an estimated 2,072.22 cubic feet of pulpwood and 21.02 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 51.68 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 25 and 35 (with 35 percent of basal area removed) and a final harvest at stand age 44 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$70.82 (Table 13), with a NPW of -$68.09 per acre (Table 9). This financially optimal rotation could produce an estimated 2,102.07 cubic feet of pulpwood and 16.46 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 45.89 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 25 and 30 (with 35 percent of basal area removed) and a final harvest at stand age 41 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$216.09 (Table 13), with a NPW of -$212.14 per acre (Table 9). This financially optimal rotation could produce an estimated 2,158.25 cubic feet of pulpwood and 13.26 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 41.38 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 25 and 30 (with 35 percent of basal area removed) and a final harvest at stand age 40 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$267.04 (Table 13), with a NPW of -$264.91 per acre (Table 9). This financially optimal rotation could

produce an estimated 2,295.89 cubic feet of pulpwood and 11.86 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 40.79 net tons of carbon per acre during one rotation (Table 1).

Slash Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 25 and 30 (with 35 percent of basal area removed) and a final harvest at stand age 40 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$285.10 (Table 13), with a NPW of -$284.17 per acre (Table 9). This financially optimal rotation could produce an estimated 2,295.89 cubic feet of pulpwood and 11.86 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 40.79 net tons of carbon per acre during one rotation (Table 1).

<u>Southern- Slash Pine - Timber Only Rotations (C = $10/ton)</u>

Slash Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 33 and 40 (with 30 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $2,194.03 (Table 14), with a NPW of $1,695.36 per acre (Table 10). This means that $2,194.03 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on

every dollar invested plus $1,695.36 per acre for managing one rotation, or $2,194.03 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 1,784.70 cubic feet of pulpwood and 20.05 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 43.74 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Slash Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $288.98 (Table 14), with a NPW of $271.93 per acre (Table 10). This financially optimal rotation could produce an estimated 1,737.10 cubic feet of pulpwood and 18.83 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 42.18 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 32 and 37 (with 35 percent of basal area removed) and a final harvest at stand age 51 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$89.95 (Table 14), with a NPW of -$87.85 per acre (Table 10). This financially optimal rotation could produce an estimated 1,818.05 cubic feet of pulpwood and 13.82 MBF of sawlogs per acre from

the thinning and final harvest (Table 18), and sequester 36.69 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 32 and 37 (with 35 percent of basal area removed) and a final harvest at stand age 49 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$198.77 (Table 14), with a NPW of -$197.07 per acre (Table 10). This financially optimal rotation could produce an estimated 1,944.34 cubic feet of pulpwood and 11.94 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 35.29 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 32 and 37 (with 35 percent of basal area removed) and a final harvest at stand age 49 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$239.07 (Table 14), with a NPW of -$238.41 per acre (Table 10). This financially optimal rotation could produce an estimated 1,944.34 cubic feet of pulpwood and11.94 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 35.29 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 32 and 37 (with 35 percent of

basal area removed) and a final harvest at stand age 47 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$256.34 (Table 14), with a NPW of -$256.03 per acre (Table 10). This financially optimal rotation could produce an estimated 2,168.49 cubic feet of pulpwood and 9.61 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 33.84 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 31 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $2,838.60 (Table 14), with a NPW of $2,209.20 per acre (Table 10). This financially optimal rotation could produce an estimated 1,548.72 cubic feet of pulpwood and 25.82 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 51.72 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 31 and 36 (with 30 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $495.48 (Table 14), with a NPW of $458.16 per acre (Table 10). This financially optimal rotation could produce an estimated 2,034.89 cubic feet of pulpwood and 19.94 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 47.59 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 30 and 37 (with 30 percent of basal area removed) and a final harvest at stand age 49 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$3.18 (Table 14), with a NPW of -$3.10 per acre (Table 10). This financially optimal rotation could produce an estimated 2,118.48 cubic feet of pulpwood and 16.88 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 44.53 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with 35 percent of basal area removed) and a final harvest at stand age 46 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$153.43 (Table 14), with a NPW of -$151.69 per acre (Table 10). This financially optimal rotation could produce an estimated 2,159.88 cubic feet of pulpwood and 13.82 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.62 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 29 and 34 (with 35 percent of

basal area removed) and a final harvest at stand age 44 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$211.84 (Table 14), with a NPW of -$210.79 per acre (Table 10). This financially optimal rotation could produce an estimated 2,310.33 cubic feet of pulpwood and 11.33 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 38.42 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 28 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 43 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$237.97 (Table 14), with a NPW of -$237.46 per acre (Table 10). This financially optimal rotation could produce an estimated 2,373.12 cubic feet of pulpwood and 10.09 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 37.24 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 27 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $3,511.10 (Table 14), with a NPW of $2,732.50 per acre (Table 10). This financially optimal rotation could produce an estimated 1,502.68 cubic feet of pulpwood and 31.06 MBF of sawlogs per acre from

the thinning and final harvest (Table 18), and sequester 60.79 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 28 and 33 (with 30 percent of basal area removed) and a final harvest at stand age 48 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $714.55 (Table 14), with a NPW of $649.12 per acre (Table 10). This financially optimal rotation could produce an estimated 2,262.07 cubic feet of pulpwood and 20.88 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 52.02 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 27 and 34 (with 30 percent of basal area removed) and a final harvest at stand age 46 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $98.98 (Table 14), with a NPW of $95.67 per acre (Table 10). This financially optimal rotation could produce an estimated 2,168.27 cubic feet of pulpwood and 18.90 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 49.48 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 25 and 30 (with 35 percent of

basal area removed) and a final harvest at stand age 41 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$98.68 (Table 14), with a NPW of -$96.88 per acre (Table 10). This financially optimal rotation could produce an estimated 2,158.25 cubic feet of pulpwood and 13.26 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 41.38 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 28 and 33 (with 25 percent of basal area removed) and a final harvest at stand age 43 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$103.39 (Table 14), with a NPW of -$101.83 per acre (Table 10). This financially optimal rotation could produce an estimated 2,772.81 cubic feet of pulpwood and 14.41 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 46.68 net tons of carbon per acre during one rotation (Table 2).

Slash Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 25 and 30 (with 35 percent of basal area removed) and a final harvest at stand age 40 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$215.28 (Table 14), with a NPW of -$214.58 per acre (Table 10). This financially optimal rotation could produce an estimated 2,295.89 cubic feet of pulpwood and 11.86 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 40.79 net tons of carbon per acre during one rotation (Table 2).

<u>Southern- Slash Pine - Timber Only Rotations (C = $37/ton)</u>

Slash Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 33 and 40 (with 30 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $3,149.09 (Table 15), with a NPW of $2,433.36 per acre (Table 11). This means that $3,149.09 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,433.36 per acre for managing one rotation, or $3,149.09 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 1,784.70 cubic feet of pulpwood and 20.05 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 43.74 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Slash Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 40 and 45 (with 25 percent of

basal area removed) and a final harvest at stand age 58 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $772.72 (Table 15), with a NPW of $729.29 per acre (Table 11). This financially optimal rotation could produce an estimated 2,103.28 cubic feet of pulpwood and 18.72 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 43.59 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 40 and 46 (with 25 percent of basal area removed) and a final harvest at stand age 55 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $210.79 (Table 15), with a NPW of $207.12 per acre (Table 11). This financially optimal rotation could produce an estimated 2,276.45 cubic feet of pulpwood and 16.05 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 41.55 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 35 and 40 (with 30 percent of basal area removed) and a final harvest at stand age 51 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $6.32 (Table 15), with a NPW of $6.27 per acre (Table 11). This financially optimal rotation could produce an estimated 2,163.09 cubic feet of pulpwood and 13.34 MBF of sawlogs per acre from the

thinning and final harvest (Table 19), and sequester 38.12 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 45 (with 35 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$89.87 (Table 15), with a NPW of -$89.70 per acre (Table 11). This financially optimal rotation could produce an estimated 2,720.34 cubic feet of pulpwood and12.29 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 39.81 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 40 (with 35 percent of basal area removed) and a final harvest at stand age 47 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$143.57 (Table 15), with a NPW of -$143.39 per acre (Table 11). This financially optimal rotation could produce an estimated 2,893.46 cubic feet of pulpwood and 8.33 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 35.92 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 36 (with 25 percent of basal area

removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $4,042.90 (Table 15), with a NPW of $3,146.50 per acre (Table 11). This financially optimal rotation could produce an estimated 1,914.72 cubic feet of pulpwood and 25.43 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 53.15 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 31 and 36 (with 30 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $1,094.92 (Table 15), with a NPW of $1,012.44 per acre (Table 11). This financially optimal rotation could produce an estimated 2,034.89 cubic feet of pulpwood and 19.94 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 47.59 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 50 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $379.39 (Table 15), with a NPW of $369.90 per acre (Table 11). This financially optimal rotation could produce an estimated 2,220.74 cubic feet of pulpwood and 17.60 MBF of sawlogs per acre from the

thinning and final harvest (Table 19), and sequester 45.72 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 40 (with 25 percent of basal area removed) and a final harvest at stand age 48 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $111.56 (Table 15), with a NPW of $110.52 per acre (Table 11). This financially optimal rotation could produce an estimated 2,999.86 cubic feet of pulpwood and 13.30 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 44.68 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 39 (with 25 percent of basal area removed) and a final harvest at stand age 47 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$15.09 (Table 15), with a NPW of -$15.03 per acre (Table 11). This financially optimal rotation could produce an estimated 2,990.12 cubic feet of pulpwood and 12.53 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 43.55 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 39 (with 25 percent of basal area

removed) and a final harvest at stand age 46 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$87.06 (Table 15), with a NPW of -$86.94 per acre (Table 11). This financially optimal rotation could produce an estimated 3,093.45 cubic feet of pulpwood and 11.35 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 42.60 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 39 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $4,977.80 (Table 15), with a NPW of $3,874.00 per acre (Table 11). This financially optimal rotation could produce an estimated 2,121.83 cubic feet of pulpwood and 30.43 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 63.41 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 28 and 33 (with 30 percent of basal area removed) and a final harvest at stand age 48 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $1,430.24 (Table 15), with a NPW of $1,299.28 per acre (Table 11). This financially optimal rotation could produce an estimated 2,262.07 cubic feet of pulpwood and 20.88 MBF of sawlogs per

acre from the thinning and final harvest (Table 19), and sequester 52.02 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 34 and 39 (with 25 percent of basal area removed) and a final harvest at stand age 49 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $566.32 (Table 15), with a NPW of $551.09 per acre (Table 11). This financially optimal rotation could produce an estimated 2,583.40 cubic feet of pulpwood and 20.87 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 53.74 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 40 (with 30 percent of basal area removed) and a final harvest at stand age 45 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $231.47 (Table 15), with a NPW of $228.58 per acre (Table 11). This financially optimal rotation could produce an estimated 3,309.22 cubic feet of pulpwood and 14.80 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 50.48 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 37 (with 35 percent of basal area

removed) and a final harvest at stand age 42 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $70.52 (Table 15), with a NPW of $70.07 per acre (Table 11). This financially optimal rotation could produce an estimated 3,383.44 cubic feet of pulpwood and 11.96 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 46.78 net tons of carbon per acre during one rotation (Table 3).

Slash Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 37 (with 35 percent of basal area removed) and a final harvest at stand age 42 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$21.59 (Table 15), with a NPW of -$21.54 per acre (Table 11). This financially optimal rotation could produce an estimated 3,383.44 cubic feet of pulpwood and 11.96 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 46.78 net tons of carbon per acre during one rotation (Table 3).

Southern- Slash Pine - Timber Only Rotations (C = $50/ton)

Slash Pine, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 33 and 40 (with 30 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $3,608.94 (Table 16), with a NPW of $2,788.69 per acre (Table 12). This means that $3,608.94 is the

maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,788.69 per acre for managing one rotation, or $3,608.94 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 1,784.70 cubic feet of pulpwood and 20.05 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 43.74 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Slash Pine, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 43 and 48 (with 25 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $1,017.42 (Table 16), with a NPW of $962.95 per acre (Table 12). This financially optimal rotation could produce an estimated 2,226.20 cubic feet of pulpwood and 19.11 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 44.90 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 42 and 51 (with 25 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 8). This

optimal management regime will generate the maximum SEV of $361.16 (Table 16), with a NPW of $355.72 per acre (Table 12). This financially optimal rotation could produce an estimated 2,267.38 cubic feet of pulpwood and 17.36 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 43.03 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 49 (with 35 percent of basal area removed) and a final harvest at stand age 55 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $109.06 (Table 16), with a NPW of $108.53 per acre (Table 12). This financially optimal rotation could produce an estimated 2,632.22 cubic feet of pulpwood and 14.55 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 42.16 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 46 (with 25 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$16.34 (Table 16), with a NPW of -$16.31 per acre (Table 12). This financially optimal rotation could produce an estimated 2,777.85 cubic feet of pulpwood and11.93 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 39.77 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 46 (with 25 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$88.68 (Table 16), with a NPW of -$88.63 per acre (Table 12). This financially optimal rotation could produce an estimated 2,777.85 cubic feet of pulpwood and 11.93 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 39.77 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 40 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $4,637.60 (Table 16), with a NPW of $3,609.20 per acre (Table 12). This financially optimal rotation could produce an estimated 2,131.80 cubic feet of pulpwood and 25.05 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 54.16 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 42 (with 25 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $1,389.24 (Table 16), with a

NPW of $1,311.15 per acre (Table 12). This financially optimal rotation could produce an estimated 2,282.78 cubic feet of pulpwood and 23.16 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 52.81 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 39 and 44 (with 25 percent of basal area removed) and a final harvest at stand age 54 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $569.41 (Table 16), with a NPW of $558.74 per acre (Table 12). This financially optimal rotation could produce an estimated 2,457.20 cubic feet of pulpwood and 20.19 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 50.09 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 43 (with 30 percent of basal area removed) and a final harvest at stand age 51 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $245.45 (Table 16), with a NPW of $243.73 per acre (Table 12). This financially optimal rotation could produce an estimated 2,857.41 cubic feet of pulpwood and 16.21 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 47.62 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 44 (with 30 percent of basal area removed) and a final harvest at stand age 49 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $82.12 (Table 16), with a NPW of $81.89 per acre (Table 12). This financially optimal rotation could produce an estimated 3,117.97 cubic feet of pulpwood and 13.83 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 46.24 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 43 (with 25 percent of basal area removed) and a final harvest at stand age 48 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$13.29 (Table 16), with a NPW of -$13.27 per acre (Table 12). This financially optimal rotation could produce an estimated 3,123.86 cubic feet of pulpwood and 12.83 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 44.89 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 38 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $5,698.10 (Table 16), with a NPW of $4,434.60 per acre (Table 12). This financially optimal rotation could produce

an estimated 2,164.42 cubic feet of pulpwood and 30.35 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 63.79 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 39 (with 30 percent of basal area removed) and a final harvest at stand age 55 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $1,789.20 (Table 16), with a NPW of $1,672.77 per acre (Table 12). This financially optimal rotation could produce an estimated 2,386.11 cubic feet of pulpwood and 25.82 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 59.23 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 34 and 41 (with 25 percent of basal area removed) and a final harvest at stand age 49 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $800.68 (Table 16), with a NPW of $779.15 per acre (Table 12). This financially optimal rotation could produce an estimated 2,614.55 cubic feet of pulpwood and 20.80 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 53.86 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 40 (with 30 percent of basal area removed) and a final harvest at stand age 45 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $398.24 (Table 16), with a NPW of $393.28 per acre (Table 12). This financially optimal rotation could produce an estimated 3,309.22 cubic feet of pulpwood and 14.80 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 50.48 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 40 (with 30 percent of basal area removed) and a final harvest at stand age 45 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $193.87 (Table 16), with a NPW of $193.01 per acre (Table 12). This financially optimal rotation could produce an estimated 3,309.22 cubic feet of pulpwood and 14.80 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 50.48 net tons of carbon per acre during one rotation (Table 4).

Slash Pine, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

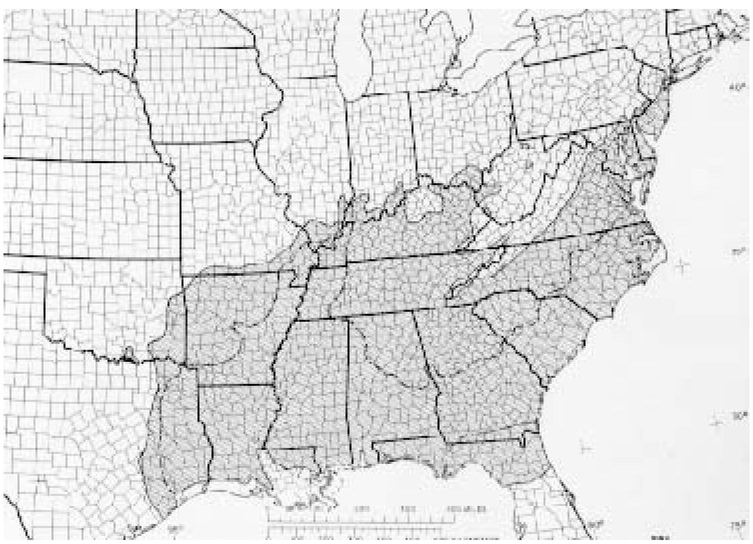
The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 40 (with 30 percent of basal area removed) and a final harvest at stand age 45 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $73.15 (Table 16), with a NPW of $73.03 per acre (Table 12). This financially optimal rotation could produce an

estimated 3,309.22 cubic feet of pulpwood and 14.80 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 50.48 net tons of carbon per acre during one rotation (Table 4).

Southern red oak (*Quercus falcata*)

Biological Information

Southern red oak (SRO) has been divided into two distinct varieties typical SRO (*Quercus falcate* var. *falcate*) and cherrybark oak (*Quercus falcate* var. *pagodifolia*). The native range of both varieties are overlaid and extend from New York, west and south to eastern Oklahoma, south to the Brazos river valley, and eastward including all of the southern states (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/quercus/falcata.htm. April 20, 2006).



- The native range of southern red oak

Typical southern red oak is common on upland sites while cherrybark is more common on moister sites. In general cherrybark presents a better form and grows larger than the typical variety. Both varieties are important for production of timber and mast production as wildlife food (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/quercus/falcata.htm. April 20, 2006).

Typical southern red oak at maturity reaches 70 to 80 feet in height with a d.b.h. of 24 to 36 inches. In closed stand conditions it produces a long, clear, relatively straight bole with a high crown. Fully stocked stands exhibit excellent self-pruning. The maximum attainable age is approximately 150 years (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/quercus/falcata.htm. April 20, 2006).

At maturity cherrybark reaches heights of 100 to 130 feet and diameters of 36 to 60 inches. This variety is fast growing for an oak and can produce up to 6 inches of d.b.h. growth in a 10-year period. The merchantable bole is often relatively branch free unlike other bottomland red oaks. At site indexes from 105 to 130 (base age 50) gross cubic foot volume growth per year can range from 188 to 275 ft^3/acre. Like the typical variety cherrybark is classified as intolerant of shade, and epicormic branching is common in recently thinned stands (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/quercus/falcata.htm. April 20, 2006).

Both varieties of southern red oak are used for a variety of special products from timber to hard mast production. In fact their uses include the majority of man's derived uses for trees and timber. Some uses include food, fuel, aesthetics, lumber, furniture, tannins, and extractives (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/quercus/falcata.htm. April 20, 2006).

Economic Background

Clatterbuck and Orr (1988) performed a financial analysis on two observed developmental patterns of cherrybark oak. The purpose was to compare the financial desirability of restricted (narrow spacing) versus unrestricted (wide spacing) stand densities. In the analysis real interest rates were used, but no initial costs were included. A \$1,200 per thousand board feet (MBF) value was used for first and second (FAS) red oak lumber. Common lumber prices were calculated as 70, 40, and 25 percent of the FAS base price for #1, #2, and #3 common respectively. Net present worth (NPW) calculations were used to discount values to 1987 dollars. The age where NPW is maximized represents the optimal rotation age for cherrybark oak. Optimal rotation lengths for unrestricted and restricted development patterns were 60 and 70 years respectively. At low interest rates (2 to 5%) optimal rotation ages for restricted and unrestricted patterns seem to represent similar investments. As interest rates increase the difference in investment potentials widen. The unrestricted pattern evidences shorter rotations, which are more favorable at higher interest rates.

Thomson (1991) conducted a single and multiperiod to determine expected returns from investments including eight sawtimber species. To do this he had to separate the species based upon how risky of an investment they were. The relative riskiness of timber investments can be determined using the capital asset pricing model (CAPM). CAPM predicts the risk-pricing relationship where “risk is measured as the covariance of returns between an asset of interest and the market portfolio”. Thompson found that in previous studies the relative riskiness of timber investments were small or even negative. Land expectation values (LEV) were calculated using the Faustmann formula, using a 5% real discount rate. It was found that one way to reduce risk in a portfolio was to add southern red oak. This addition will decrease return on a short-term investment however; in the long-run moderate risk aversion leads to increased wealth accumulation due to observed losses from riskier investments.

Literature Cited

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Species Southern red oak Region South

Site indices 90, 100 and 110 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 9-in. inside bark top diameter for trees with a minimum of 12 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 11-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 20 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 25, 30 and 35% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.245225694 and 0.434027778, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Clark et al. (1986) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Yp = 0.05008(D^2H)^{1.06363}$$

$$Ys = 0.10728(D^2)^{0.90476}(H)^{1.06363}$$

where:

Yp = dry-weight (lbs.) of stemwood and bark of trees < 11.0 in. d.b.h

Ys = dry-weight (lbs.) of stemwood and bark of trees ≥ 11.0 in d.b.h

D = diameter at breast height (in.)

H = total height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 1.6% and 1.24% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $210/mbf (Scribner) (Timber Mart South, Inc. 2000-2005) and pulpwood price was assumed to be $16.44/cord (Timber Mart South, Inc. 2000-2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of southern red oak plantations in the South.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$60.00	Only once	Year 0	
Seedlings[b] (436 seedlings/ac)	$130.80	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).

[b]Data from Hans M. Williams, personal communication, Stephen F. Austin State University, December 19, 2006.

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Table 1. Total tons of carbon sequestered per acre for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	48.19	48.52	47.55	52.10	44.00	44.00
100	57.95	59.29	50.67	50.67	50.67	46.50
110	67.15	61.53	56.86	56.86	53.75	53.75

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	52.10	52.10	52.10	50.59	46.46	46.46
100	59.38	59.29	59.29	54.61	53.50	50.37
110	67.15	68.25	63.84	56.86	56.86	56.59

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	52.10	53.96	53.96	53.96	53.96	53.86
100	61.06	61.15	61.15	60.17	60.17	61.18
110	68.65	68.65	66.91	67.30	66.07	66.07

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	52.10	53.96	53.96	53.96	53.86	54.70
100	61.15	61.15	61.15	62.01	63.03	63.03
110	68.65	68.65	67.76	71.44	71.44	70.53

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	28-34-**60**[2] (35%)[3]	29-34-**60** (35%)	<29-34-**59**>[4](35%)	<33-38-**60**>(30%)	<28-33-**56**>(35%)	<28-33-**56**>(35%)
100	28-33-**60** (30%)	29-38-**59** (30%)	<27-32-**55**>(35%)	<27-32-**55**>(35%)	<27-32-**55**>(35%)	<26-31-**52**>(35%)
110	27-33-**60** (25%)	25-32-**56** (30%)	<26-33-**53**>(35%)	<26-33-**53**>(35%)	<24-30-**52**>(35%)	<24-30-**52**>(35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	33-38-**60**[2] (30%)[3]	33-38-**60** (30%)	<33-38-**60**>[4](30%)	<32-42-**59**>(35%)	<29-34-**58**>(35%)	<29-34-**58**>(35%)
100	27-38-**60** (30%)	29-38-**59** (30%)	<29-38-**59**>(30%)	<29-38-**56**>(35%)	<29-38-**55**>(35%)	<27-34-**54**>(35%)
110	27-33-**60** (25%)	28-36-**60** (25%)	<26-37-**56**>(30%)	<26-33-**53**>(35%)	<26-33-**53**>(35%)	<27-34-**52**>(35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	33-38-**60**[2] (30%)[3]	36-45-**60** (30%)	36-45-**60** (30%)	<36-45-**60**>[4](30%)	<36-45-**60**>(30%)	<45-51-**60**>(30%)
100	29-41-**60** (30%)	35-42-**60** (25%)	35-42-**60** (25%)	<37-45-**58**>(30%)	<37-45-**58**>(30%)	<44-49-**59**>(30%)
110	29-37-**60** (25%)	29-37-**60** (25%)	32-40-**58** (25%)	40-45-**57** (25%)	<39-44-**56>**(25%)	<39-44-**56>**(25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	33-38-**60**[2] (30%)[3]	36-45-**60** (30%)	36-45-**60** (30%)	<36-45-**60**>[4] (30%)	<45-51-**60**>(30%)	<54-**60**>(35%)
100	35-42-**60** (25%)	35-42-**60** (25%)	35-42-**60** (25%)	41-47-**60** (25%)	<54-**60**>(35%)	<54-**60**>(35%)
110	29-37-**60** (25%)	29-37-**60** (25%)	38-43-**58** (25%)	53-**60** (35%)	<53-**60**>(35%)	<53-**59**>(35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$1,567.74	$98.01	-$251.33	-$344.67	-$364.79	-$371.88
100	$1,918.07	$183.10	-$221.13	-$328.13	-$359.97	-$369.63
110	$2,233.10	$260.95	-$191.65	-$315.35	-$354.76	-$367.43

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$1,843.96	$259.27	-$155.53	-$278.32	-$321.87	-$340.87
100	$2,260.54	$385.25	-$104.47	-$251.20	-$305.58	-$329.90
110	$2,637.67	$499.54	-$52.68	-$223.01	-$288.54	-$318.26

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,635.98	$715.08	$123.41	-$98.90	-$199.91	-$253.63
100	$3,196.94	$941.00	$237.20	-$29.00	-$151.49	-$217.88
110	$3,746.33	$1,160.04	$349.45	$43.03	-$100.93	-$180.13

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$3,017.33	$939.96	$259.25	-$11.67	-$140.23	-$210.96
100	$3,657.22	$1,214.02	$405.15	$81.23	-$75.44	-$162.75
110	$4,281.97	$1,478.37	$548.03	$176.64	-$7.66	-$112.07

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,014.41	$103.28	-$254.65	-$345.70	-$365.24	-$372.01
100	$2,464.56	$193.46	-$225.05	-$329.71	-$360.46	-$369.85
110	$2,869.35	$278.19	-$195.59	-$318.20	-$355.45	-$367.65

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,369.34	$273.19	-$157.44	-$279.24	-$322.18	-$340.96
100	$2,904.60	$407.05	-$105.86	-$252.31	-$306.00	-$330.05
110	$3,389.19	$526.37	-$53.55	-$224.31	-$289.04	-$318.45

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$3,387.02	$753.50	$124.93	-$99.19	-$200.06	-$253.68
100	$4,107.81	$991.55	$240.11	-$29.11	-$151.63	-$217.93
110	$4,813.73	$1,222.36	$354.42	$43.20	-$101.06	-$180.20

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for southern red oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$3,877.02	$990.46	$262.44	-$11.71	-$140.33	-$211.00
100	$4,699.23	$1,279.24	$410.13	$81.48	-$75.49	-$162.78
110	$5,501.98	$1,557.79	$555.82	$177.17	-$7.67	-$112.09

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for southern red oak plantations by soil productivity and real alternative rates of return in the southern United States). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	28-34-**60**[3] (35%)[4]	590.66	0	659.77	0	1,028.75	16.33	2,279.18	16.33
	5.0%	29-34-**60** (35%)	653.75	0	652.74	0	1,034.42	16.28	2,340.91	16.28
	7.5%	29-34-**59** (35%)	653.75	0	652.74	0	1,039.26	15.64	2,345.75	15.64
	10.0%	33-38-**60** (30%)	724.27	0	739.96	0	1,338.23	15.92	2,802.46	15.92
	12.5%	28-33-**56** (35%)	590.66	0	613.34	0	1,479.64	11.80	2,683.64	11.80
	15.0%	28-33-**56** (35%)	590.66	0	613.34	0	1,479.64	11.80	2,683.64	11.80
100	2.5%	28-33-**60** (30%)	636.82	0	685.41	0	1,236.46	19.32	2,558.69	19.32
	5.0%	29-38-**59** (30%)	692.55	0	920.14	0	1,261.28	18.50	2,873.97	18.50
	7.5%	27-32-**55** (35%)	684.93	0	704.80	0	1,157.84	15.34	2,547.57	15.34
	10.0%	27-32-**55** (35%)	684.93	0	704.80	0	1,157.84	15.34	2,547.57	15.34
	12.5%	27-32-**55** (35%)	684.93	0	704.80	0	1,157.84	15.34	2,547.57	15.34
	15.0%	26-31-**52** (35%)	632.55	0	657.43	0	1,807.67	10.41	3,097.65	10.41
110	2.5%	27-33-**60** (25%)	591.73	0	722.25	0	1,447.70	22.04	2,761.68	22.04
	5.0%	25-32-**56** (30%)	574.93	0	774.69	0	1,367.00	19.24	2,716.62	19.24
	7.5%	26-33-**53** (35%)	771.56	0	902.54	0	1,218.68	16.13	2,892.78	16.13
	10.0%	26-33-**53** (35%)	771.56	0	902.54	0	1,218.68	16.13	2,892.78	16.13
	12.5%	24-30-**52** (35%)	589.26	0	742.61	0	1,453.65	14.74	2,785.52	14.74
	15.0%	24-30-**52** (35%)	589.26	0	742.61	0	1,454.65	14.74	2,785.52	14.74

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 18. Volume removed from the financially optimal schedules for southern red oak plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	33-38-**60**[3] (30%)[4]	724.27	0	739.96	0	1,338.23	15.92	2,802.46	15.92
	5.0%	33-38-**60** (30%)	724.27	0	739.96	0	1,338.23	15.92	2,802.46	15.92
	7.5%	33-38-**60** (30%)	724.27	0	739.96	0	1,338.23	15.92	2,802.46	15.92
	10.0%	32-42-**59** (35%)	803.64	0	1,022.05	0	1,025.66	14.78	2,851.35	14.78
	12.5%	29-34-**58** (35%)	653.75	0	652.74	0	1,148.26	14.49	2,454.75	14.49
	15.0%	29-34-**58** (35%)	653.75	0	652.74	0	1,148.26	14.49	2,454.75	14.49
100	2.5%	27-38-**60** (30%)	584.45	0	930.59	0	1,240.53	19.20	2,755.57	19.20
	5.0%	29-38-**59** (30%)	692.55	0	920.14	0	1,261.28	18.50	2,873.97	18.50
	7.5%	29-38-**59** (30%)	692.55	0	920.14	0	1,261.28	18.50	2,873.97	18.50
	10.0%	29-38-**56** (35%)	809.99	0	1,011.75	0	1,119.23	15.60	2,940.97	15.60
	12.5%	29-38-**55** (35%)	809.99	0	1,011.75	0	1,251.15	14.33	3,072.89	14.33
	15.0%	27-34-**54** (35%)	684.93	0	806.30	0	1,398.49	13.53	2,889.72	13.53
110	2.5%	27-33-**60** (25%)	591.73	0	722.25	0	1,447.70	22.04	2,761.68	22.04
	5.0%	28-36-**60** (25%)	636.84	0	855.80	0	1,448.74	21.89	2,941.38	21.89
	7.5%	26-37-**56** (30%)	657.37	0	1,041.68	0	1,378.33	18.80	3,077.38	18.80
	10.0%	26-33-**53** (35%)	771.56	0	902.54	0	1,218.68	16.13	2,892.78	16.13
	12.5%	26-33-**53** (35%)	771.56	0	902.54	0	1,218.68	16.13	2,892.78	16.13
	15.0%	27-34-**52** (35%)	837.80	0	957.48	0	1,542.01	13.87	3,337.29	13.87

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 19. Volume removed from the financially optimal schedules for southern red oak plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	33-38-**60**[3] (30%)[4]	724.27	0	739.96	0	1,338.23	15.92	2,802.46	15.92
	5.0%	36-45-**60** (30%)	847.04	0	1,087.80	0	1,303.09	15.24	3,157.93	15.24
	7.5%	36-45-**60** (30%)	847.04	0	1,087.80	0	1,303.09	15.24	3,157.93	15.24
	10.0%	36-45-**60** (30%)	847.04	0	1,087.80	0	1,303.09	15.24	3,157.93	15.24
	12.5%	36-45-**60** (30%)	847.04	0	1,087.80	0	1,303.09	15.24	3,157.93	15.24
	15.0%	45-51-**60** (30%)	1,221.59	0	1,148.69	0	1,379.29	12.18	3,749.57	12.18
100	2.5%	29-41 **60** (30%)	692.55	0	1,068.51	0	1,244.37	18.84	3,005.43	18.84
	5.0%	35-42-**60** (30%)	797.26	0	902.63	0	1,359.53	18.63	3,059.42	18.63
	7.5%	35-42-**60** (30%)	797.26	0	902.63	0	1,359.53	18.63	3,059.42	18.63
	10.0%	37-45-**58** (30%)	1,051.73	0	1,153.23	0	1,181.99	16.45	3,386.95	16.45
	12.5%	37-45-**58** (30%)	1,051.73	0	1,153.23	0	1,181.99	16.45	3,386.95	16.45
	15.0%	44-49-**59** (30%)	1,378.44	0	1,242.31	0	1,091.71	15.36	3,712.46	15.36
110	2.5%	29-37-**60** (25%)	677.35	0	890.75	0	1,430.57	21.81	2,998.67	21.81
	5.0%	29-37-**60** (25%)	677.35	0	890.75	0	1,430.57	21.81	2,998.67	21.81
	7.5%	32-40-**58** (25%)	802.07	0	975.93	0	1,418.68	19.81	3,196.68	19.81
	10.0%	40-45-**57** (25%)	1,139.82	0	1,088.97	0	1,471.14	17.69	3,699.93	17.69
	12.5%	39-44-**56** (25%)	1,096.95	0	1,061.81	0	1,651.94	16.54	3,810.70	16.54
	15.0%	39-44-**56** (25%)	1,096.95	0	1,061.81	0	1,651.94	16.54	3,810.70	16.54

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 20. Volume removed from the financially optimal schedules for southern red oak plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	33-38-**60**[3] (30%)[4]	724.27	0	739.96	0	1,338.23	15.92	2,802.46	15.92
	5.0%	36-45-**60** (30%)	847.04	0	1,007.80	0	1,303.09	15.24	3,157.93	15.24
	7.5%	36-45-**60** (30%)	847.04	0	1,007.80	0	1,303.09	15.24	3,157.93	15.24
	10.0%	36-45-60 (30%)	847.04	0	1,007.80	0	1,303.09	15.24	3,157.93	15.24
	12.5%	45-51-**60** (30%)	1,221.59	0	1,148.69	0	1,379.29	12.18	3,749.57	12.18
	15.0%	54-**60** (35%)	1,867.66	0	-[5]	-	2,630.62	8.85	4,498.28	8.85
100	2.5%	35-42-**60** (25%)	797.26	0	902.63	0	1,359.53	18.63	3,059.42	18.63
	5.0%	35-42-60 (25%)	797.26	0	902.63	0	1,359.53	18.63	3,059.42	18.63
	7.5%	35-42-**60** (25%)	797.26	0	902.63	0	1,359.53	18.63	3,059.42	18.63
	10.0%	41-47-**60** (25%)	1,026.00	0	1,024.29	0	1,261.75	17.77	3,312.04	17.77
	12.5%	54-**60** (35%)	2,155.69	0	-	-	2,142.51	13.52	4,298.20	13.52
	15.0%	54-**60** (35%)	2,155.69	0	-	-	2,142.51	13.52	4,298.20	13.52
110	2.5%	29-37-**60** (25%)	677.35	0	890.75	0	1,430.57	21.81	2,998.67	21.81
	5.0%	29-37-**60** (25%)	677.35	0	890.75	0	1,430.57	21.81	2,998.67	21.81
	7.5%	38-43-**58** (25%)	1,055.11	0	1,036.59	0	1,361.70	19.09	3,453.40	19.09
	10.0%	53-**60** (35%)	2,394.97	0	-	-	1,668.58	17.91	4,063.55	17.91
	12.5%	53-**60** (35%)	2,394.97	0	-	-	1,668.58	17.91	4,063.55	17.91
	15.0%	53-**59** (35%)	2,394.97	0	-	-	1,914.26	16.29	4,309.23	16.29

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted

Table 21. Financially optimal thinning and final harvest schedules for southern red oak plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	90	28-34-**60**[2] (35%)[3]	33-38-**60** (30%)	0%	33-38-**60** (30%)	0%	33-38-**60** (30%)	0%
	100	28-33-**60** (30%)	27-38-**60** (30%)	0%	29-41-**60** (30%)	0%	35-42-**60** (25%)	0%
	110	27-33-**60** (25%)	27-33-**60** (25%)	0%	29-37-**60** (25%)	0%	29-37-**60** (25%)	0%
5.00%	90	29-34-**60** (35%)	33-38-**60** (30%)	0%	36-45-**60** (30%)	0%	36-45-**60** (30%)	0%
	100	29-38-**59** (30%)	29-38-**59** (30%)	0%	35-42-**60** (25%)	2%	35-42-**60** (25%)	2%
	110	25-32-**56** (30%)	28-36-**60** (25%)	7%	29-37-**60** (25%)	7%	29-37-**60** (25%)	7%
7.50%	90	<29-34-**59**>[4](35%)	<33-38-**60**> (30%)	2%	36-45-**60** (30%)	2%	36-45-**60** (30%)	2%
	100	<27-32-**55**> (35%)	<29-38-**59**> (30%)	7%	35-42-**60** (25%)	9%	35-42-**60** (25%)	9%
	110	<26-33-**53**> (35%)	<26-37-**56**> (30%)	6%	32-40-**58** (25%)	9%	38-43-**58** (25%)	9%
10.00%	90	<33-38-**60**> (30%)	<32-42-**59**> (35%)	-2%	<36-45-**60**> (30%)	0%	<36-45-**60**> (30%)	0%
	100	<27-32-**55**> (35%)	<29-38-**56**> (35%)	2%	<37-45-**58**> (30%)	5%	41-47-**60** (25%)	9%
	110	<26-33-**53**> (35%)	<26-33-**53**> (35%)	0%	40-45-**57** (25%)	8%	53-**60** (35%)	13%
12.50%	90	<28-33-**56**> (35%)	<29-34-**58**> (35%)	4%	<36-45-**60**> (30%)	7%	<45-51-**60**> (30%)	7%
	100	<27-32-**55**> (35%)	<29-38-**55**> (35%)	0%	<37-45-**58**> (30%)	5%	<54-**60**> (35%)	9%
	110	<24-30-**52**> (35%)	<26-33-**53**> (35%)	2%	<39-44-**56>** (25%)	8%	<53-**60**> (35%)	15%
15.00%	90	<28-33-**56**> (35%)	<29-34-**58**> (35%)	4%	<45-51-**60**> (30%)	7%	<54-**60**> (35%)	7%
	100	<26-31-**52**> (35%)	<27-34-**54**> (35%)	4%	<44-49-**59**> (30%)	13%	<54-**60**> (35%)	15%
	110	<24-30-**52**> (35%)	<27-34-**52**> (35%)	0%	<39-44-**56>** (25%)	8%	<53-**59**> (35%)	13%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning
[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for southern red oak plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	90	2,014.41	2,369.34	18%	3,387.02	68%	3,877.02	92%
	100	2,464.56	2,904.60	18%	4,107.81	67%	4,699.23	91%
	110	2,869.35	3,389.19	18%	4,813.73	68%	5,501.98	92%
5.00%	90	103.28	273.19	165%	753.50	630%	990.46	859%
	100	193.46	407.05	110%	991.55	413%	1,279.24	561%
	110	278.19	526.37	89%	1,222.36	339%	1,557.79	460%
7.50%	90	-254.65	-157.44		124.93		262.44	
	100	-225.05	-105.86		240.11		410.13	
	110	-195.59	-53.55		354.42		555.82	
10.00%	90	-345.70	-279.24		-99.19		-11.71	
	100	-329.71	-252.31		-29.11		81.48	
	110	-318.20	-224.31		43.20		177.17	
12.50%	90	-365.24	-322.18		-200.06		-140.33	
	100	-360.46	-306.00		-151.63		-75.49	
	110	-355.45	-289.04		-101.06		-7.67	
15.00%	90	-372.01	-340.96		-253.68		-211.00	
	100	-369.85	-330.05		-217.93		-162.78	
	110	-367.65	-318.45		-180.20		-112.09	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>Southern- Southern red oak - Timber Only Rotations (C = $0/ton)</u>

Southern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 28 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $2,014.41 (Table 13), with a NPW of $1,567.74 per acre (Table 9). This means that $2,014.41 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,567.74 per acre for managing one rotation, or $2,014.41 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 2,279.18 cubic feet of pulpwood and 16.33 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 48.19 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Southern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 29 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $103.28 (Table 13), with a NPW of $98.01 per acre (Table 9). This financially optimal rotation could

produce an estimated 2,340.91 cubic feet of pulpwood and 16.28 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 48.52 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 29 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$254.65 (Table 13), with a NPW of -$251.33 per acre (Table 9). This financially optimal rotation could produce an estimated 2,345.75 cubic feet of pulpwood and 15.64 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 47.55 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$345.70 (Table 13), with a NPW of -$344.67 per acre (Table 9). This financially optimal rotation could produce an estimated 2,802.46 cubic feet of pulpwood and 15.92 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 52.10 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 28 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 56 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$365.24 (Table 13), with a NPW of -$364.79 per acre (Table 9). This financially optimal rotation could produce an estimated 2,683.64 cubic feet of pulpwood and 11.80 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 44.00 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 28 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 56 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$372.01 (Table 13), with a NPW of -$371.88 per acre (Table 9). This financially optimal rotation could produce an estimated 2,683.64 cubic feet of pulpwood and 11.80 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 44.00 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 28 and 33 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $2,465.56 (Table 13), with a NPW of $1,918.07 per acre (Table 9). This financially optimal rotation could produce an estimated 2,558.69 cubic feet of pulpwood and 19.32 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 57.95 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 29 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $193.46 (Table 13), with a NPW of $183.10 per acre (Table 9). This financially optimal rotation could produce an estimated 2,873.97 cubic feet of pulpwood and 18.50 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 59.29 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 27 and 32 (with 35 percent of basal area removed) and a final harvest at stand age 55 are conducted (Table 5). This

optimal management regime will generate the maximum SEV of -$225.05 (Table 13), with a NPW of -$221.13 per acre (Table 9). This financially optimal rotation could produce an estimated 2,547.57 cubic feet of pulpwood and 15.34 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 50.67 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 27 and 32 (with 35 percent of basal area removed) and a final harvest at stand age 55 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$329.71 (Table 13), with a NPW of -$328.13 per acre (Table 9). This financially optimal rotation could produce an estimated 2,547.57 cubic feet of pulpwood and 15.34 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 50.67 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 27 and 32 (with 35 percent of basal area removed) and a final harvest at stand age 55 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$360.46 (Table 13), with a NPW of -$359.97 per acre (Table 9). This financially optimal rotation could produce an estimated 2,547.57 cubic feet of pulpwood and 15.34 MBF of sawlogs per

acre from the thinning and final harvest (Table 17), and sequester 50.67 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 26 and 31 (with 35 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$369.85 (Table 13), with a NPW of -$369.63 per acre (Table 9). This financially optimal rotation could produce an estimated 3,097.65 cubic feet of pulpwood and 10.41 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 46.50 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 27 and 33 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $2,869.35 (Table 13), with a NPW of $2,233.10 per acre (Table 9). This financially optimal rotation could produce an estimated 2,761.68 cubic feet of pulpwood and 22.04 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 67.15 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 25 and 32 (with 30 percent of basal area removed) and a final harvest at stand age 56 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $278.19 (Table 13), with a NPW of $260.95 per acre (Table 9). This financially optimal rotation could produce an estimated 2,716.62 cubic feet of pulpwood and 19.24 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 61.53 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 26 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$195.59 (Table 13), with a NPW of -$191.65 per acre (Table 9). This financially optimal rotation could produce an estimated 2,892.78 cubic feet of pulpwood and 16.13 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 56.86 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 26 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$318.20 (Table 13), with a NPW of -$315.35 per acre (Table 9). This financially optimal rotation could produce an estimated 2,892.78 cubic feet of pulpwood and 16.13 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 56.86 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 24 and 30 (with 35 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$355.45 (Table 13), with a NPW of -$354.76 per acre (Table 9). This financially optimal rotation could produce an estimated 2,785.52 cubic feet of pulpwood and 14.74 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 40.79 net tons of carbon per acre during one rotation (Table 1).

Southern red oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 24 and 30 (with 35 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 5). This

optimal management regime will generate the maximum SEV of -$367.65 (Table 13), with a NPW of -$367.43 per acre (Table 9). This financially optimal rotation could produce an estimated 2,785.52 cubic feet of pulpwood and 14.74 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 53.75 net tons of carbon per acre during one rotation (Table 1).

Southern- Southern red oak - Timber + Carbon Rotations (C = $10/ton)

Southern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $2,369.34 (Table 14), with a NPW of $1,843.96 per acre (Table 10). This means that $2,369.34 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,843.96 per acre for managing one rotation, or $2,369.34 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 2,802.46 cubic feet of pulpwood and 15.92 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 52.10 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Southern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $273.19 (Table 14), with a NPW of $259.27 per acre (Table 10). This financially optimal rotation could produce an estimated 2,802.46 cubic feet of pulpwood and 15.92 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 52.10 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$157.44 (Table 14), with a NPW of -$155.53 per acre (Table 10). This financially optimal rotation could produce an estimated 2,802.46 cubic feet of pulpwood and 15.92 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 52.10 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 32 and 42 (with 30 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$279.24 (Table 14), with a NPW of -$278.32 per acre (Table 10). This financially optimal rotation could produce an estimated 2,851.35 cubic feet of pulpwood and 14.78 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 50.59 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 29 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$322.18 (Table 14), with a NPW of -$321.87 per acre (Table 10). This financially optimal rotation could produce an estimated 2,454.75 cubic feet of pulpwood and 14.49 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 46.46 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 29 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$340.96 (Table 14), with a NPW of -$340.87 per acre (Table 10). This financially optimal rotation could produce an estimated 2,454.75 cubic feet of pulpwood and 14.49 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 46.46 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 27 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $2,904.60 (Table 14), with a NPW of $2,260.54 per acre (Table 10). This financially optimal rotation could produce an estimated 2,755.57 cubic feet of pulpwood and 19.20 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 59.38 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 29 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 6). This

optimal management regime will generate the maximum SEV of $407.05 (Table 14), with a NPW of $385.25 per acre (Table 10). This financially optimal rotation could produce an estimated 2,873.97 cubic feet of pulpwood and 18.50 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 59.29 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 29 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$105.86 (Table 14), with a NPW of -$104.47 per acre (Table 10). This financially optimal rotation could produce an estimated 2,873.97 cubic feet of pulpwood and 18.50 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 59.29 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 29 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 56 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$252.31 (Table 14), with a NPW of -$251.20 per acre (Table 10). This financially optimal rotation could produce an estimated 2,940.97 cubic feet of pulpwood and 15.60 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 54.61 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 29 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 55 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$306.00 (Table 14), with a NPW of -$305.58 per acre (Table 10). This financially optimal rotation could produce an estimated 3,072.89 cubic feet of pulpwood and 14.33 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 53.50 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 27 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 54 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$330.05 (Table 14), with a NPW of -$329.90 per acre (Table 10). This financially optimal rotation could produce an estimated 2,889.72 cubic feet of pulpwood and 13.53 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 50.37 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 27 and 33 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $3,389.19 (Table 14), with a NPW of $2,637.67 per acre (Table 10). This financially optimal rotation could produce an estimated 2,761.68 cubic feet of pulpwood and 22.04 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 67.15 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 28 and 36 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $526.37 (Table 14), with a NPW of $499.54 per acre (Table 10). This financially optimal rotation could produce an estimated 2,941.38 cubic feet of pulpwood and 21.89 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 68.25 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 26 and 37 (with 30 percent of basal area removed) and a final harvest at stand age 56 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$53.55 (Table 14), with a NPW of -$52.68 per acre (Table 10). This financially optimal rotation could produce an estimated 3,077.38 cubic feet of pulpwood and 18.80 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 63.84 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 26 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$224.31 (Table 14), with a NPW of -$223.01 per acre (Table 10). This financially optimal rotation could produce an estimated 2,892.78 cubic feet of pulpwood and 16.13 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 56.86 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 26 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 6). This

optimal management regime will generate the maximum SEV of -$289.04 (Table 14), with a NPW of -$288.54 per acre (Table 10). This financially optimal rotation could produce an estimated 2,892.78 cubic feet of pulpwood and 16.13 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 56.86 net tons of carbon per acre during one rotation (Table 2).

Southern red oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 27 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$318.45 (Table 14), with a NPW of -$318.26 per acre (Table 10). This financially optimal rotation could produce an estimated 3,337.29 cubic feet of pulpwood and 13.87 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 56.59 net tons of carbon per acre during one rotation (Table 2).

Southern- Southern red oak - Timber + Carbon Rotations (C = $37/ton)

Southern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $3,387.02 (Table 15),

with a NPW of $2,635.98 per acre (Table 11). This means that $3,387.02 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,635.98 per acre for managing one rotation, or $3,387.02 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 2,802.46 cubic feet of pulpwood and 15.92 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 52.10 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Southern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $753.50 (Table 15), with a NPW of $715.08 per acre (Table 11). This financially optimal rotation could produce an estimated 3,157.93 cubic feet of pulpwood and 15.24 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 53.96 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $124.93 (Table 15), with a NPW of $123.41 per acre (Table 11). This financially optimal rotation could produce an estimated 3,157.93 cubic feet of pulpwood and 15.24 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 53.96 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$99.19 (Table 15), with a NPW of -$98.90 per acre (Table 11). This financially optimal rotation could produce an estimated 3,157.93 cubic feet of pulpwood and 15.24 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 53.96 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This

optimal management regime will generate the maximum SEV of -$200.06 (Table 15), with a NPW of -$199.91 per acre (Table 11). This financially optimal rotation could produce an estimated 3,157.93 cubic feet of pulpwood and 15.24 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 53.96 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 45 and 51 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$253.68 (Table 15), with a NPW of -$253.63 per acre (Table 11). This financially optimal rotation could produce an estimated 3,749.57 cubic feet of pulpwood and 12.18 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 53.86 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 29 and 41 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $4,107.81 (Table 15), with a NPW of $3,196.94 per acre (Table 11). This financially optimal rotation could produce an estimated 3,005.43 cubic feet of pulpwood and 18.84 MBF of sawlogs per

acre from the thinning and final harvest (Table 19), and sequester 61.06 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 35 and 42 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $991.55 (Table 15), with a NPW of $941.00 per acre (Table 11). This financially optimal rotation could produce an estimated 3,059.42 cubic feet of pulpwood and 18.63 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 61.15 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 35 and 42 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $240.11 (Table 15), with a NPW of $237.20 per acre (Table 11). This financially optimal rotation could produce an estimated 3,059.42 cubic feet of pulpwood and 18.63 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 61.15 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 37 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$29.11 (Table 15), with a NPW of -$29.00 per acre (Table 11). This financially optimal rotation could produce an estimated 3,386.95 cubic feet of pulpwood and 16.45 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 60.17 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 37 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$151.63 (Table 15), with a NPW of -$151.49 per acre (Table 11). This financially optimal rotation could produce an estimated 3,386.95 cubic feet of pulpwood and 16.45 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 60.17 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 44 and 49 (with 30 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$217.93 (Table 15), with a NPW of -$217.88 per acre (Table 11). This financially optimal rotation could produce an estimated 3,712.46 cubic feet of pulpwood and 15.36 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 61.18 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 29 and 37 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $4,813.73 (Table 15), with a NPW of $3,746.33 per acre (Table 11). This financially optimal rotation could produce an estimated 2,998.67 cubic feet of pulpwood and 21.81 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 68.65 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 29 and 37 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This

optimal management regime will generate the maximum SEV of $1,222.36 (Table 15), with a NPW of $1,160.04 per acre (Table 11). This financially optimal rotation could produce an estimated 2,998.67 cubic feet of pulpwood and 21.81 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 68.65 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 32 and 40 (with 25 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $354.42 (Table 15), with a NPW of $349.45 per acre (Table 11). This financially optimal rotation could produce an estimated 3,196.68 cubic feet of pulpwood and 19.81 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 66.91 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 40 and 45 (with 25 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $43.20 (Table 15), with a NPW of $43.03 per acre (Table 11). This financially optimal rotation could produce an estimated 3,699.93 cubic feet of pulpwood and 17.69 MBF of sawlogs per acre from the

thinning and final harvest (Table 19), and sequester 67.30 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 39 and 44 (with 25 percent of basal area removed) and a final harvest at stand age 56 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$101.06 (Table 15), with a NPW of -$100.93 per acre (Table 11). This financially optimal rotation could produce an estimated 3,810.70 cubic feet of pulpwood and 16.54 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 66.07 net tons of carbon per acre during one rotation (Table 3).

Southern red oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 39 and 44 (with 25 percent of basal area removed) and a final harvest at stand age 56 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$180.20 (Table 15), with a NPW of -$180.13 per acre (Table 11). This financially optimal rotation could produce an estimated 3,810.70 cubic feet of pulpwood and 16.54 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 66.07 net tons of carbon per acre during one rotation (Table 3).

<u>Southern- Southern red oak - Timber + Carbon Rotations (C = $50/ton)</u>

Southern red oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $3,877.02 (Table 16), with a NPW of $3,017.33 per acre (Table 12). This means that $3,877.02 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $3,017.33 per acre for managing one rotation, or $3,877.02 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 2,802.46 cubic feet of pulpwood and 15.92 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 52.10 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Southern red oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This

optimal management regime will generate the maximum SEV of $990.46 (Table 16), with a NPW of $939.96 per acre (Table 12). This financially optimal rotation could produce an estimated 3,157.93 cubic feet of pulpwood and 15.24 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 53.96 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $262.44 (Table 16), with a NPW of $259.25 per acre (Table 12). This financially optimal rotation could produce an estimated 3,157.93 cubic feet of pulpwood and 15.24 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 53.96 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$11.71 (Table 16), with a NPW of -$11.67 per acre (Table 12). This financially optimal rotation could produce an estimated 3,157.93 cubic feet of pulpwood and 15.24 MBF of sawlogs per acre from

the thinning and final harvest (Table 20), and sequester 53.96 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 45 and 51 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$140.33 (Table 16), with a NPW of -$140.23 per acre (Table 12). This financially optimal rotation could produce an estimated 3,749.57 cubic feet of pulpwood and 12.18 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 53.86 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 54 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$211.00 (Table 16), with a NPW of -$210.96 per acre (Table 12). This financially optimal rotation could produce an estimated 4,498.28 cubic feet of pulpwood and 8.85 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 54.70 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 35 and 42 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $4,699.23 (Table 16), with a NPW of $3,657.22 per acre (Table 12). This financially optimal rotation could produce an estimated 3,059.42 cubic feet of pulpwood and 18.63 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 61.15 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 35 and 42 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $1,279.24 (Table 16), with a NPW of $1,214.02 per acre (Table 12). This financially optimal rotation could produce an estimated 3,059.42 cubic feet of pulpwood and 18.63 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 61.15 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 35 and 42 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $410.13 (Table 16), with a NPW of $405.15 per acre (Table 12). This financially optimal rotation could produce an estimated 3,059.42 cubic feet of pulpwood and 18.63 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 61.15 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 41 and 47 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $81.48 (Table 16), with a NPW of $81.23 per acre (Table 12). This financially optimal rotation could produce an estimated 3,312.04 cubic feet of pulpwood and 17.77 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 62.01 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 54 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal

management regime will generate the maximum SEV of -$75.49 (Table 16), with a NPW of -$75.44 per acre (Table 12). This financially optimal rotation could produce an estimated 4,298.20 cubic feet of pulpwood and 13.52 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 63.03 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 54 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$162.78 (Table 16), with a NPW of -$162.75 per acre (Table 12). This financially optimal rotation could produce an estimated 4,298.20 cubic feet of pulpwood and 13.52 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 63.03 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 29 and 37 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $5,501.98 (Table 16), with a NPW of $4,281.97 per acre (Table 12). This financially optimal rotation could produce an estimated 2,998.67 cubic feet of pulpwood and 21.81 MBF of sawlogs per

acre from the thinning and final harvest (Table 20), and sequester 68.65 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 29 and 37 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $1,557.79 (Table 16), with a NPW of $1,478.37 per acre (Table 12). This financially optimal rotation could produce an estimated 2,998.67 cubic feet of pulpwood and 21.81 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 68.65 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 38 and 43 (with 25 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $555.82 (Table 16), with a NPW of $548.03 per acre (Table 12). This financially optimal rotation could produce an estimated 3,453.40 cubic feet of pulpwood and 19.09 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 67.76 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 53 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $177.17 (Table 16), with a NPW of $176.64 per acre (Table 12). This financially optimal rotation could produce an estimated 4,063.55 cubic feet of pulpwood and 17.91 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 71.44 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 53 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$7.67 (Table 16), with a NPW of -$7.66 per acre (Table 12). This financially optimal rotation could produce an estimated 4,063.55 cubic feet of pulpwood and 17.91 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 71.44 net tons of carbon per acre during one rotation (Table 4).

Southern red oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

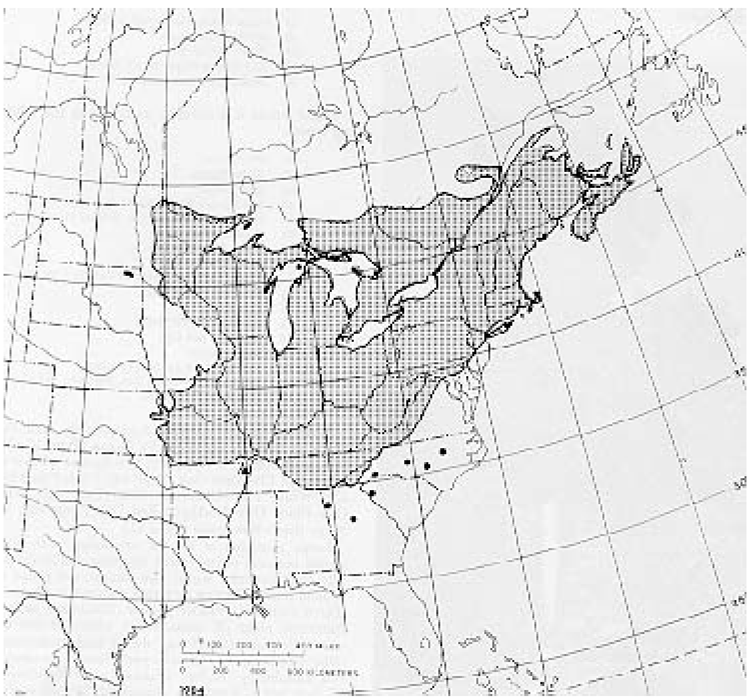
The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 53 (with 35 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$112.09 (Table 16), with a NPW of -$112.07 per acre (Table 12). This financially optimal rotation could produce an estimated 4,309.23 cubic feet of pulpwood and 16.29 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 70.53 net tons of carbon per acre during one rotation (Table 4).

Literature Review

Sugar maple (*Acer saccharum*)

Biological Information

Sugar maple is one of the largest and more important of the hardwood species in North America (Godman et al. 2004). Mature sugar maple generally ranges from 70 to 90 feet in height, with a d.b.h. from 24 to 36 inches (CSMREP 2004). The native range extends across the Northeastern United States, westward to the headwaters of the Mississippi, and southward through Kentucky and Tennessee (Godman et al. 2004).



- The native range of sugar maple

Sugar maple occurs where annual precipitation averages between 20 and 80 inches, with growing seasons from 80 to 260 days (CSMREP 2004 Godman et al. 2004). Natural stands grow best in well drained loams and grow poorly on dry shallow soils (Godman et al. 2004).

Across its range aspen is a major component of seven forest cover types, Sugar maple, Sugar maple-Basswood, Sugar maple-Beech-Yellow birch, Beech-Sugar maple, Black cherry-maple, Red spruce-Sugar maple-Beech, and Aspen. It is a common associate in seventeen other forest cover types, and is an occasional to rare component in ten types (Godman et al. 2004).

Sugar maple is highly shade tolerant and can persist for long periods beneath a dense forest canopy. In many areas, sugar maple is a dominant species in gaps created by dying American elms. Throughout much of its natural range, sugar maple codominates climax stands with American basswood (*Tilia americana*), or yellow birch (*Betula alleghaniensis*). In the absence of disturbances, sugar maple and its tolerant associates will replace shade intolerant conifers and hardwoods (Godman et al. 2004).

Economic Background

Sugar maple is the major species in volume and value in the northern forests of the Lake States. Because of past demand, nearly 90 percent of the sugar maple area consists of second-growth stands (Godman and Mendel 1978). Sugar maple occupies approximately 31 million acres, and represents 6 percent of the hardwood sawtimber volume in the United States (Godman et al. 2004).

Sugar maples are the principal source of maple sugar, a multi-million dollar industry. They are also the source of a variety of other highly valued products. These products include, furniture, paneling, flooring, veneer, gunstocks, tool handles, plywood dies, cutting blocks, woodenware, novelty products, sporting goods, bowling pins, and musical instruments. Other uses include rolling pins, scoops, apple grinders, cheese presses, cabinet work, and fire wood (CSMREP 2004).

Sugar maple seedlings do not grow well on open or bare areas created by heavy logging or clearcutting. It can only be perpetuated after clearcutting if many large saplings are present before cutting (Lorimer and Locey 1994). If even-aged stands are the desired condition, then the shelterwood regeneration method is recommended (Godman and Tubbs 1973). The site index range for Sugar maple for base age 50 trees is 40 to 80 feet (Godman et al. 2004). On good sites financial maturity should be reached when trees are between 15 and 30 inches in diameter(Godman and Mendel 1978). At age 50 on average and good sites trees in the canopy should average 6-10 inches in d.b.h. and grow 1-2 inches in diameter per decade (Lorimer and Locey 1994).

Table1: Financial-maturity diameters of sugar maple for selected growth and grade combinations at given rates of value increase
(In Inches)

Butt log grade	Diameter increase (D.b.h. growth-inches)			Diameter and 1/2 log height increase (D.b.h. growth-inches)			Diameter and 1 grade increase (D.b.h. growth-inches)			Diameter and 1/2 log plus 1 grade increase (D.b.h. growth-inches)		
	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2	1.4	1.8	2.2
6 PERCENT RATE OF VALUE INCREASE												
3	18	19	21	21	22	24	No grade increase expected[2]					
2	15	17	19	18	20	22	23	24	25+[3]	26+	26+	26+
1	([1])	([1])	([1])	15	18	20	No grade increase expected[4]					
4 PERCENT RATE OF VALUE INCREASE												
3	22	23	23	27+	28+	28+	No grade increase expected[2]					
2	20	22	24	25	26	28+	28+	28+	28+	28+	28+	28+
1	16	19	22	24	26	27	No grade increase expected[4]					
2 PERCENT RATE OF VALUE INCREASE												
3	30+	30+	30+	30+	30+	30+	No grade increase expected[2]					
2	30+	30+	30+	30+	30+	30+	No grade increase expected[2]					
1	30	30+	30+	30+	30+	30+	No grade increase expected[4]					

[1]Maximum rate of value increase for butt log grade 1 trees is 5.6 percent or lower considering only diameter increase.

[2]Because of large diameter.

[3]+ indicates that diameter will be higher than indicated but is beyond limitations established for analysis.

[4]Maximum grade considered in present study.

Final harvests in sugar maple stands should not be made at intervals of less than 60 years, however trees may not reach biologic maturity (14-16 inches) until about age 100 (Lorimer and Locey 1994). Shelterwood regeneration in sugar maple requires that after the initial cut the residual canopy should admit about 40% of full sunlight (Lorimer and Locey 1994 Godman and Tubbs 1973). Since the residual trees are serving as the seed source, they must be vigorous and of good quality (Lorimer and Locey 1994). The remaining overstory should be removed when the young trees are 3 to 5 feet tall, or within 3 to 8 years (Lorimer and Locey 1994 Godman and Tubbs 1973). Thinnings in stands 50 years old should be conducted as 75% cut from bellow, and 25% cut from above for trees removed. In 70 year old stands thinning should be conducted as 100% of trees removed cut from below (Nowak and Marquis 1997). First thinnings in sugar maple stands are generally conducted between the ages of 40 and 70 years of age. Thinnings are typically done at 10 to 15 year intervals, leaving approximately 7 foot gaps between crop tree crowns. The recommended remnant trees per acre vary depending upon average stand diameter as shown in Table 2 (Lorimer and Locey, 1994).

Table2: Recommended number of trees to leave standing after thinning young and mature northern hardwoods

Average Stand Diameter (Inches) of Overstory Trees Only	Number of Trees/Acre	Average Distance Between Overstory Trees (Feet) After Thinning
6	300	12
8	200	15
10	150	17
12	100	21
14	90	22

Dry weight equations for sugar maple were not found in the original literature search. However a green weight equation for the bole was as follows: Bole Weight(lbs)= 44.79+0.184*bole length(ft)*DBH^2(in) (Winsauer and Steinhilb 1980). Information was not found concerning number of mills or mill production in the area of interest. Minimum cutting volumes for sugar maple were also not found. Some of this information may yet be found in the literature, however some may only be found through contacting professionals.

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Species___sugar maple__________ Region______Central States_________________

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 3.15, 4.30, and 4.90 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 25 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183482143 and 0.446428571, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Perala and Alban (1994) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$Y = 0.02953D^{1.826}H^{1.036}*1000$$

where:

Y = component dry-weight (kg.)

D = diameter at breast height (cm.)

H = height (cm.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $355/mbf (International 1/4) (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005) and pulpwood price was assumed to be $17/cord (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of sugar maple plantations in the Central States.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$152.60	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]The seedling cost was estimated based on the seedling prices from Minnesota DNR State Forest Nursery (http://www.dnr.state.mn.us/forestry/nurseries/pricelist.html. January 18, 2006) and Lee's Nursery, Inc. (http://www.leenursery.com/Seedling2006Catalog.pdf. January 18, 2006).

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Table 1. Total tons of carbon sequestered per acre for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	20.07	19.78	19.75	19.92	19.76	18.83
80	26.33	26.03	25.09	25.09	24.57	24.57
90	29.05	29.01	27.54	26.90	23.38	22.02

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	20.07	20.07	20.07	19.88	19.88	20.24
80	26.33	26.03	25.77	25.44	25.09	25.39
90	29.05	29.01	28.82	27.30	24.21	24.21

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	20.38	20.38	20.38	20.38	20.26	17.05
80	26.78	26.87	26.87	26.57	26.34	22.19
90	29.94	29.04	29.08	24.21	24.21	24.21

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	20.38	20.38	20.38	20.26	20.26	17.05
80	26.78	26.87	26.87	26.57	22.19	22.19
90	29.04	29.04	29.08	24.21	24.21	24.21

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	<65-**90**[2]>[3] (25%)[4]	<62-**90**> (25%)	<59-**90**> (30%)	<59-66-**90**> (30%)	<59-66-**89**> (30%)	<59-66-**84**> (30%)
80	<51-**90**> (25%)	<51-**89**> (30%)	<51-57-**86**> (30%)	<51-57-**86**> (30%)	<51-57-**84**> (30%)	<51-57-**84**> (30%)
90	52-**90** (30%)	53-85-**90** (30%)	<50-58-**83**> (30%)	<51-56-**83**> (30%)	<**69**> (30%)	<**66**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	65-**90**[2](25%)[3]	<65-**90>**[4] (25%)	<65-**90>** (25%)	<65-**89>** (25%)	<65-**89>** (25%)	<70-**89>** (20%)
80	51-**90** (30%)	<51-**89>** (30%)	<62-68-**88>** (20%)	<58-63-**86>** (30%)	<58-**86>** (30%)	<61-**87>** (25%)
90	52-**90** (30%)	<53-85-**90>** (30%)	<63-**88>** (25%)	<52-59-**83>** (30%)	<**90>**	<**90>**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	73-**90**[2] (20%)[3]	<73-**90**>[4] (20%)	<73-**90**> (20%)	<73-**90**> (20%)	<75-**90**> (20%)	<**90**>
80	71-**90** (25%)	<73-**90**> (25%)	<73-**90**> (25%)	<73-**89**> (25%)	<73-**88**> (25%)	<**90**>
90	71-**90** (25%)	73-**90** (20%)	<73-**89**> (20%)	<**90**>	<**90**>	<**90**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	73-**90**[2] (20%)[3]	<73-**90**>[4] (20%)	<73-**90**> (20%)	<75-**90**> (20%)	<75-**90**> (20%)	<**90**>
80	71-**90** (25%)	73-**90** (25%)	<73-**90**> (25%)	<73-**89**> (25%)	<**90**>	<**90**>
90	73-**90** (20%)	73-**90** (20%)	<73-**89**> (20%)	<**90**>	<**90**>	<**90**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$60.47	-$369.06	-$400.00	-$401.34	-$400.07	-$398.93
80	$57.94	-$353.21	-$396.34	-$400.51	-$399.85	-$398.87
90	$166.91	-$340.17	-$394.70	-$400.16	-$399.22	-$398.05

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$72.85	-$300.23	-$362.36	-$378.69	-$385.25	-$388.60
80	$232.55	-$261.80	-$346.04	-$369.36	-$379.17	-$384.32
90	$363.89	-$235.15	-$335.64	-$363.33	-$374.32	-$380.43

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$439.51	-$111.49	-$259.46	-$316.99	-$345.05	-$360.65
80	$709.26	-$6.04	-$204.17	-$283.39	-$322.72	-$344.84
90	$910.92	$60.00	-$170.07	-$261.60	-$306.78	-$332.76

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$617.24	-$20.46	-$209.89	-$287.28	-$325.69	-$347.20
80	$946.53	$118.10	-$135.70	-$241.96	-$295.54	-$325.83
90	$1,180.16	$202.76	-$90.22	-$212.59	-$274.27	-$309.80

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$67.61	-$373.46	-$400.55	-$401.41	-$400.08	-$398.93
80	$64.79	-$357.64	-$346.60	-$400.61	-$399.87	-$398.87
90	$186.64	-$344.24	-$395.61	-$400.29	-$399.33	-$398.09

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$81.46	-$303.81	-$362.87	-$378.76	-$385.25	-$388.60
80	$260.04	-$265.09	-$346.60	-$369.46	-$379.18	-$384.32
90	$406.91	-$237.95	-$336.17	-$363.45	-$374.32	-$380.43

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$491.47	-$112.82	-$259.82	-$317.05	-$345.06	-$360.65
80	$793.10	-$6.11	-$204.47	-$283.45	-$322.73	-$344.84
90	$1,018.60	$60.72	-$170.32	-$261.65	-$306.79	-$332.76

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the central United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$690.20	-$20.71	-$210.18	-$287.33	-$325.70	-$347.20
80	$1,058.42	$119.51	-$135.89	-$242.00	-$295.54	-$325.83
90	$1,319.66	$205.18	-$90.35	-$212.63	-$274.27	-$309.80

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for sugar maple plantations by soil productivity and real alternative rates of return in the central United States). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	65-**90**[3] (25%)[4]	626.90	0	-[5]	-	2,273.61	7.92	2,900.51	7.92
	5.0%	62-**90** (25%)	585.97	0	-	-	2,266.27	7.89	2,852.24	7.89
	7.5%	59-**90** (30%)	575.53	0	-	-	2,203.64	7.78	2,779.17	7.78
	10.0%	59-66-**90** (30%)	575.53	0	560.09	0	1,686.43	7.34	2,822.05	7.34
	12.5%	59-66-**89** (30%)	575.53	0	560.09	0	1,716.14	6.62	2,851.76	6.62
	15.0%	59-66-**84** (30%)	575.53	0	560.09	0	1,759.87	3.86	2,895.49	3.86
80	2.5%	51-**90** (30%)	558.39	0	-	-	2,624.71	10.57	2,138.10	10.57
	5.0%	51-**89** (30%)	558.39	0	-	-	2,641.02	10.10	3,199.41	10.10
	7.5%	51-57-**86** (30%)	558.39	0	566.53	0	2,037.87	8.18	3,162.79	8.18
	10.0%	51-57-**86** (30%)	558.39	0	-	-	2,699.73	8.97	3,258.12	8.97
	12.5%	51-57-**84** (30%)	558.39	0	566.53	0	2,179.56	6.60	3,304.48	6.60
	15.0%	51-57-**84** (30%)	558.39	0	566.53	0	2,179.56	6.60	3,304.48	6.60
90	2.5%	52-**90** (30%)	675.19	0	-	-	2,611.55	13.13	3,286.74	13.13
	5.0%	53-85-**90** (30%)	703.82	0	862.94	2.32	1,734.46	10.25	3,301.22	12.57
	7.5%	50-58-**83** (30%)	557.58	0	627.09	0	2,304.07	8.00	3,488.74	8.00
	10.0%	51-56-**83** (30%)	629.63	0	560.35	0	2,248.43	7.81	3,438.41	7.81
	12.5%	**69**	-	-	-	-	3,877.48	0	3,877.48	0
	15.0%	**66**	-	-	-	-	3,559.39	0	3,559.39	0

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 18. Volume removed from the financially optimal schedules for sugar maple plantations by soil productivity and real alternative rates of return in the central United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	65-**90**[3] (25%)[4]	626.90	0	-[5]	-	2,610.07	6.29	2,610.07	6.29
	5.0%	65-**90** (25%)	626.90	0	-	-	2,273.61	7.92	2,900.51	7.92
	7.5%	65-**90** (25%)	626.90	0	-	-	2,273.61	7.92	2,900.51	7.92
	10.0%	65-**89** (25%)	626.90	0	-	-	2,291.48	7.27	2,918.38	7.27
	12.5%	65-**89** (25%)	626.90	0	-	-	2,291.48	7.27	2,918.38	7.27
	15.0%	70-**89** (20%)	552.84	0	-	-	2,481.98	7.11	3,034.82	7.11
80	2.5%	51-**90** (30%)	558.39	0	-	-	2,624.71	10.57	3,183.10	10.57
	5.0%	51-**89** (30%)	558.39	0	-	-	2,641.02	10.10	3,199.41	10.10
	7.5%	51-**88** (30%)	558.39	0	-	-	2,660.74	8.60	3,219.13	9.60
	10.0%	58-63-**86** (30%)	771.79	0	628.80	0	1,940.86	7.81	3,341.45	7.81
	12.5%	58-**86** (30%)	771.79	0	-	-	2,646.54	7.82	3,418.33	7.82
	15.0%	61-**87** (25%)	685.15	0	-	-	2,725.22	8.46	3,410.37	8.46
90	2.5%	52-**90** (30%)	675.19	0	-	-	2,611.55	13.13	3,286.74	13.13
	5.0%	53-85-**90** (30%)	703.82	0	862.94	2.32	1,734.46	10.25	3,301.22	12.57
	7.5%	63-**88** (25%)	824.47	0	-	-	2,693.10	11.73	3,517.57	11.73
	10.0%	52-59-**83** (30%)	675.19	0	669.08	0	2,236.30	7.79	3,580.57	7.79
	12.5%	**90**	-	-	-	-	4,098.69	2.82	4,098.69	2.82
	15.0%	**90**	-	-	-	-	4,098.69	2.82	4,098.69	2.82

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for sugar maple plantations by soil productivity and real alternative rates of return in the central United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	73-**90**[3] (20%)[4]	580.15	0	-[5]	-	2,380.82	7.83	2,960.97	7.83
	5.0%	73-**90** (20%)	580.15	0	-	-	2,380.82	7.83	2,960.97	7.83
	7.5%	73-**90** (20%)	580.15	0	-	-	2,380.82	7.83	2,960.97	7.83
	10.0%	73-**90** (20%)	580.15	0	-	-	2,380.82	7.83	2,960.97	7.83
	12.5%	75-**90** (20%)	588.40	0	-	-	2,355.28	7.76	2,943.68	7.76
	15.0%	**90**	-	-	-	-	2,610.07	6.29	2,610.07	6.29
80	2.5%	71-**90** (25%)	931.10	0	-	-	2,588.66	10.00	3,519.76	10.00
	5.0%	73-**90** (25%)	961.27	0	-	-	2,593.64	9.86	3,554.91	9.86
	7.5%	73-**90** (25%)	961.27	0	-	-	2,593.64	9.86	3,554.91	9.86
	10.0%	73-**89** (25%)	961.27	0	-	-	2,609.38	9.39	3,570.65	9.39
	12.5%	73-**88** (25%)	961.27	0	-	-	2,649.99	8.76	3,611.26	8.76
	15.0%	**90**	-	-	-	-	3,014.86	8.17	3,014.86	8.17
90	2.5%	71-**90** (25%)	957.92	0	-	-	2,629.23	12.65	3,587.15	12.65
	5.0%	73-**90** (20%)	807.67	0	-	-	2,668.28	12.70	3,475.95	12.70
	7.5%	73-**89** (20%)	807.67	0	-	-	2,737.78	12.14	3,545.45	12.14
	10.0%	**90**	-	-	-	-	4,098.69	2.82	4,098.69	2.82
	12.5%	**90**	-	-	-	-	4,098.69	2.82	4,098.69	2.82
	15.0%	**90**	-	-	-	-	4,098.69	2.82	4,098.69	2.82

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for sugar maple plantations by soil productivity and real alternative rates of return in the central United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	73-**90**[3] (20%)[4]	580.15	0	-[5]	-	2,380.82	7.83	2,960.97	7.83
	5.0%	73-**90** (20%)	580.15	0	-	-	2,380.82	7.83	2,960.97	7.83
	7.5%	73-**90** (20%)	580.15	0	-	-	2,380.82	7.83	2,960.97	7.83
	10.0%	75-**90** (20%)	588.40	0	-	-	2,355.28	7.76	2,943.68	7.76
	12.5%	75-**90** (20%)	588.40	0	-	-	2,355.28	7.76	2,943.68	7.76
	15.0%	**90**	-	-	-	-	2,610.07	6.29	2,610.07	6.29
80	2.5%	71-**90** (25%)	931.10	0	-	-	2,588.66	10.00	3,519.76	10.00
	5.0%	73-**90** (25%)	961.27	0	-	-	2,593.64	9.86	3,554.91	9.86
	7.5%	73-**90** (25%)	961.27	0	-	-	2,593.64	9.86	3,554.91	9.86
	10.0%	73-**89** (25%)	961.27	0	-	-	2,609.38	9.39	3,570.65	9.39
	12.5%	**90**	-	-	-	-	3,014.86	8.17	3,014.86	8.17
	15.0%	**90**	-	-	-	-	3,014.86	8.17	3,014.86	8.17
90	2.5%	73-**90** (20%)	807.67	0	-	-	2,668.28	12.70	3,475.95	12.70
	5.0%	73-**90** (20%)	807.67	0	-	-	2,668.28	12.70	3,475.95	12.70
	7.5%	73-**89** (20%)	807.67	0	-	-	2,737.78	12.14	3,545.45	12.14
	10.0%	**90**	-	-	-	-	4,098.69	2.82	4,098.69	2.82
	12.5%	**90**	-	-	-	-	4,098.69	2.82	4,098.69	2.82
	15.0%	**90**	-	-	-	-	4,098.69	2.82	4,098.69	2.82

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for sugar maple plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	<65-**90**[2]>[3] (25%)[4]	65-**90**(25%)	0%	73-**90** (20%)	0%	73-**90** (20%)	0%
	80	<51-**90**> (25%)	51-**90** (30%)	0%	71-**90** (25%)	0%	71-**90** (25%)	0%
	90	52-**90** (30%)	52-**90** (30%)	0%	71-**90** (25%)	0%	73-**90** (20%)	0%
5.00%	70	<62-**90**> (25%)	<65-**90**> (25%)	0%	<73-**90**> (20%)	0%	<73-**90**> (20%)	0%
	80	<51-**89**> (30%)	<51-**89**> (30%)	0%	<73-**90**> (25%)	1%	73-**90** (25%)	1%
	90	53-85-**90** (30%)	<53-85-**90**> (30%)	0%	73-**90** (20%)	0%	73-**90** (20%)	0%
7.50%	70	<59-**90**> (30%)	<65-**90**> (25%)	0%	<73-**90**> (20%)	0%	<73-**90**> (20%)	0%
	80	<51-57-**86**> (30%)	<62-68-**88**> (20%)	2%	<73-**90**> (25%)	5%	<73-**90**> (25%)	5%
	90	<50-58-**83**> (30%)	<63-**88**> (25%)	6%	<73-**89**> (20%)	7%	<73-**89**> (20%)	7%
10.00%	70	<59-66-**90**> (30%)	<65-**89**> (25%)	-1%	<73-**90**> (20%)	0%	<75-**90**> (20%)	0%
	80	<51-57-**86**> (30%)	<58-63-**86**> (30%)	0%	<73-**89**> (25%)	3%	<73-**89**> (25%)	3%
	90	<51-56-**83**> (30%)	<52-59-**83**> (30%)	0%	<**90**>	8%	<**90**>	8%
12.50%	70	<59-66-**89**> (30%)	<65-**89**> (25%)	0%	<75-**90**> (20%)	1%	<75-**90**> (20%)	1%
	80	<51-57-**84**> (30%)	<58-**86**> (30%)	2%	<73-**88**> (25%)	5%	<**90**>	7%
	90	<**69**> (30%)	<**90**>	30%	<**90**>	30%	<**90**>	30%
15.00%	70	<59-66-**84**> (30%)	<70-**89**> (20%)	6%	<**90**>	7%	<**90**>	7%
	80	<51-57-**84**> (30%)	<61-**87**> (25%)	4%	<**90**>	7%	<**90**>	7%
	90	<**66**>	<**90**>	36%	<**90**>	36%	<**90**>	36%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for sugar maple plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	-67.61	81.46		491.47		690.20	
	80	64.79	260.04	301%	793.10	1124%	1,058.42	1534%
	90	186.64	406.91	118%	1,018.60	446%	1,319.66	607%
5.00%	70	-373.46	-303.81		-112.82		-20.71	
	80	-357.64	-265.09		-6.11		119.51	
	90	-344.24	-237.95		60.72		205.18	
7.50%	70	-400.55	-362.87		-259.82		-210.18	
	80	-346.60	-346.60		-204.47		-135.89	
	90	-395.61	-336.17		-170.32		-90.35	
10.00%	70	-401.41	-378.76		-317.05		-287.33	
	80	-400.61	-369.46		-283.45		-242.00	
	90	-400.29	-363.45		-261.65		-212.63	
12.50%	70	-400.08	-385.25		-345.06		-325.70	
	80	-399.87	-379.18		-322.73		-295.54	
	90	-399.33	-374.32		-306.79		-274.27	
15.00%	70	-398.93	-388.60		-360.65		-347.20	
	80	-398.87	-384.32		-344.84		-325.83	
	90	-398.09	-380.43		-332.76		-309.80	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>Central States- Sugar maple - Timber Only Rotations (C = $0/ton)</u>

Sugar maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 65 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$67.61 (Table 13), with a NPW of -$60.47 per acre (Table 9). This means that -$67.61 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$60.47 per acre for managing one rotation, or -$67.61 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,900.51 cubic feet of pulpwood and 7.92 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 20.07 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Sugar maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 62 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$373.46 (Table 13), with a NPW of -$369.06 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,852.24 cubic feet of pulpwood and 7.89 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.78 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 59 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$400.55 (Table 13), with a NPW of -$400.00 per acre (Table 9). This financially optimal rotation would produce an estimated 2,779.17 cubic feet of pulpwood and 7.78 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.75 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 59 and 66 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$401.41 (Table 13), with a NPW of -$401.34 per acre (Table 9). This financially optimal rotation would produce an estimated 2,822.05 cubic feet of pulpwood and 7.34 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.92 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 59 and 66 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 5). This optimal management regime will generate the maximum SEV of -$400.08 (Table 13), with a NPW of -$400.07 per acre (Table 9). This financially optimal rotation would produce an estimated 2,851.76 cubic feet of pulpwood and 6.62 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.76 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 59 and 66 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 5). This optimal management regime will generate the maximum SEV of -$398.93 (Table 13), with a NPW of -$398.93 per acre (Table 9). This financially optimal rotation would produce an estimated 2,895.49 cubic feet of pulpwood and 3.86 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 18.83 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of $64.79 (Table 13), with a NPW of $57.94 per acre (Table 9). This financially optimal rotation would produce an

estimated 3,138.10 cubic feet of pulpwood and 10.57 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 26.33 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 5). This optimal management regime will generate the maximum SEV of -$357.64 (Table 13), with a NPW of -$353.21 per acre (Table 9). This financially optimal rotation would produce an estimated 3,199.41 cubic feet of pulpwood and 10.10 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 26.03 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 57 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 86 (Table 5). This optimal management regime will generate the maximum SEV of -$397.08 (Table 13), with a NPW of -$396.34 per acre (Table 9). This financially optimal rotation would produce an estimated 3,162.79 cubic feet of pulpwood and 8.18 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 25.09 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 57 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 86 (Table 5). This optimal management regime will generate the maximum SEV of -$400.61 (Table 13), with a NPW of -$400.51 per acre (Table 9). This financially optimal rotation would produce an estimated 3,162.79 cubic feet of pulpwood and 8.18 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 25.09 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 57 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 5). This optimal management regime will generate the maximum SEV of -$399.87 (Table 13), with a NPW of -$399.85 per acre (Table 9). This financially optimal rotation would produce an estimated 3,304.48 cubic feet of pulpwood and 6.60 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 24.57 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 57 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 5). This optimal management regime will generate the maximum SEV of -$398.87 (Table 13), with a NPW of -$398.87 per acre (Table 9). This financially optimal rotation would

produce an estimated 3,304.48 cubic feet of pulpwood and 6.60 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 24.57 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of $186.64 (Table 13), with a NPW of $166.91 per acre (Table 9). This financially optimal rotation would produce an estimated 3,286.74 cubic feet of pulpwood and 13.13 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 29.05 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 53 and 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$344.24 (Table 13), with a NPW of -$340.17 per acre (Table 9). This financially optimal rotation would produce an estimated 3,301.22 cubic feet of pulpwood and 12.57 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 29.01 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 58 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 5). This optimal management regime will generate the maximum SEV of -$395.61 (Table 13), with a NPW of -$394.70 per acre (Table 9). This financially optimal rotation would produce an estimated 3,488.74 cubic feet of pulpwood and 8.00 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 27.54 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 5). This optimal management regime will generate the maximum SEV of -$400.29 (Table 13), with a NPW of -$400.16 per acre (Table 9). This financially optimal rotation would produce an estimated 3,438.41 cubic feet of pulpwood and 7.81 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 26.90 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 69 (Table 5). This optimal management regime will generate the maximum SEV of -$399.33 (Table 13), with a NPW of -$399.22 per acre (Table 9). This financially optimal rotation would produce an estimated 3,877.48 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre

from the final harvest (Table 17), and sequester 23.38 net tons of carbon per acre during one rotation (Table 1).

Sugar maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 66 (Table 5). This optimal management regime will generate the maximum SEV of -$398.09 (Table 13), with a NPW of -$398.05 per acre (Table 9). This financially optimal rotation would produce an estimated 3,559.39 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.02 net tons of carbon per acre during one rotation (Table 1).

<u>Central States- Sugar maple - Timber Only Rotations (C = $10/ton)</u>

Sugar maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 65 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of $81.46 (Table 14), with a NPW of $72.85 per acre (Table 10). This means that $81.46 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $72.85 per acre for managing one rotation, or $81.46 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,900.51 cubic feet of pulpwood and 7.92 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 20.07 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Sugar maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 65 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$303.81 (Table 14), with a NPW of -$300.23 per acre (Table 10). This financially optimal rotation would produce an estimated 2,900.51 cubic feet of pulpwood and 7.92 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 20.07 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 65 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$362.87 (Table 14), with a NPW of -$362.36 per acre (Table 10). This financially optimal rotation would produce an estimated 2,900.51 cubic feet of pulpwood and 7.92 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 20.07 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 65 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$378.76 (Table 14), with a NPW of -$378.69 per acre (Table 10). This financially optimal rotation would produce an estimated 2,918.38 cubic feet of pulpwood and 7.27 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.88 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 65 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$385.25 (Table 14), with a NPW of -$385.25 per acre (Table 10). This financially optimal rotation would produce an estimated 2,918.38 cubic feet of pulpwood and 7.27 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.88 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$388.60 (Table 14),

with a NPW of -\$388.60 per acre (Table 10). This financially optimal rotation would produce an estimated 3,034.82 cubic feet of pulpwood and 7.11 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 20.24 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of \$260.04 (Table 14), with a NPW of \$232.55 per acre (Table 10). This financially optimal rotation would produce an estimated 3,183.10 cubic feet of pulpwood and 10.57 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.33 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -\$265.09 (Table 14), with a NPW of -\$261.80 per acre (Table 10). This financially optimal rotation would produce an estimated 3,199.41 cubic feet of pulpwood and 10.10 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.03 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 6). This optimal management regime will generate the maximum SEV of -$346.60 (Table 14), with a NPW of -$346.04 per acre (Table 10). This financially optimal rotation would produce an estimated 3,219.13 cubic feet of pulpwood and 9.60 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.77 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 63 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 86 (Table 6). This optimal management regime will generate the maximum SEV of -$369.46 (Table 14), with a NPW of -$369.36 per acre (Table 10). This financially optimal rotation would produce an estimated 3,341.45 cubic feet of pulpwood and 7.81 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.44 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 58 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 86 (Table 6). This optimal management regime will generate the maximum SEV of -$379.18 (Table 14), with a NPW of -$379.17 per acre (Table 10). This financially optimal rotation would

produce an estimated 3,418.33 cubic feet of pulpwood and 7.82 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 24.21 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 61 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 6). This optimal management regime will generate the maximum SEV of -$384.32 (Table 14), with a NPW of -$384.32 per acre (Table 10). This financially optimal rotation would produce an estimated 3,410.37 cubic feet of pulpwood and 8.46 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 24.21 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of $406.91 (Table 14), with a NPW of $363.89 per acre (Table 10). This financially optimal rotation would produce an estimated 3,286.74 cubic feet of pulpwood and 13.13 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 29.05 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 53 and 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$237.95 (Table 14), with a NPW of -$235.15 per acre (Table 10). This financially optimal rotation would produce an estimated 3,301.22 cubic feet of pulpwood and 12.57 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 29.01 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 63 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 6). This optimal management regime will generate the maximum SEV of -$336.17 (Table 14), with a NPW of -$335.64 per acre (Table 10). This financially optimal rotation would produce an estimated 3,517.57 cubic feet of pulpwood and 11.73 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 28.82 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 59 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 6). This optimal management regime will generate the maximum SEV of -$363.45 (Table 14), with a NPW of -$363.33 per acre (Table 10). This financially optimal rotation

would produce an estimated 3,580.57 cubic feet of pulpwood and 7.79 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 27.30 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$374.32 (Table 14), with a NPW of -$374.32 per acre (Table 10). This financially optimal rotation would produce an estimated 4,098.69 cubic feet of pulpwood and 2.82 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 24.21 net tons of carbon per acre during one rotation (Table 2).

Sugar maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$380.43 (Table 14), with a NPW of -$380.43 per acre (Table 10). This financially optimal rotation would produce an estimated 4,098.69 cubic feet of pulpwood and 2.82 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 24.21 net tons of carbon per acre during one rotation (Table 2).

Central States-Sugar maple - Timber Only Rotations (C = $37/ton)

Sugar maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $491.47 (Table 15), with a NPW of $439.51 per acre (Table 11). This means that $491.47 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $439.51 per acre for managing one rotation, or $491.47 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,960.97 cubic feet of pulpwood and 7.83 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 20.38 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Sugar maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$112.82 (Table 15), with a NPW of -$111.49 per acre (Table 11). This financially optimal rotation would

produce an estimated 2,960.97 cubic feet of pulpwood and 7.83 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 20.38 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$259.82 (Table 15), with a NPW of -$259.46 per acre (Table 11). This financially optimal rotation would produce an estimated 2,960.97 cubic feet of pulpwood and 7.83 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 20.38 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$317.05 (Table 15), with a NPW of -$316.99 per acre (Table 11). This financially optimal rotation would produce an estimated 2,960.97 cubic feet of pulpwood and 7.83 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 20.38 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$345.06 (Table 15), with a NPW of -$345.05 per acre (Table 11). This financially optimal rotation would produce an estimated 2,943.68 cubic feet of pulpwood and 7.76 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 20.26 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$360.65 (Table 15), with a NPW of -$360.65 per acre (Table 11). This financially optimal rotation would produce an estimated 2,610.07 cubic feet of pulpwood and 6.29 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 17.05 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 71 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $793.10 (Table 15), with a NPW of $709.26 per acre (Table 11). This financially optimal rotation would produce an estimated 3,519.76 cubic feet of pulpwood and 10.00 MBF of sawlogs per

acre from the thinning and final harvest (Table 19), and sequester 26.78 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$6.11 (Table 15), with a NPW of -$6.04 per acre (Table 11). This financially optimal rotation would produce an estimated 3,554.91 cubic feet of pulpwood and 9.86 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.87 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$204.47 (Table 15), with a NPW of -$204.17 per acre (Table 11). This financially optimal rotation would produce an estimated 3,554.91 cubic feet of pulpwood and 9.86 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.87 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 25 percent of

basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of -$283.45 (Table 15), with a NPW of -$283.39 per acre (Table 11). This financially optimal rotation would produce an estimated 3,570.65 cubic feet of pulpwood and 9.39 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.57 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 7). This optimal management regime will generate the maximum SEV of -$322.73 (Table 15), with a NPW of -$322.72 per acre (Table 11). This financially optimal rotation would produce an estimated 3,311.26 cubic feet of pulpwood and 8.76 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.34 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$344.84 (Table 15), with a NPW of -$344.84 per acre (Table 11). This financially optimal rotation would produce an estimated 3,014.86 cubic feet of pulpwood and 8.17 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 22.19 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 71 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $1,018.60 (Table 15), with a NPW of $910.92 per acre (Table 11). This financially optimal rotation would produce an estimated 3,587.15 cubic feet of pulpwood and 12.65 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 29.94 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $60.72 (Table 15), with a NPW of $60.00 per acre (Table 11). This financially optimal rotation would produce an estimated 3,475.95 cubic feet of pulpwood and 12.70 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 29.04 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of -$170.32 (Table 15),

with a NPW of -$170.07 per acre (Table 11). This financially optimal rotation would produce an estimated 3,545.45 cubic feet of pulpwood and 12.14 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 29.08 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$261.65 (Table 15), with a NPW of -$261.60 per acre (Table 11). This financially optimal rotation would produce an estimated 4,098.69 cubic feet of pulpwood and 2.82 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 24.21 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$306.79 (Table 15), with a NPW of -$306.78 per acre (Table 11). This financially optimal rotation would produce an estimated 4,098.69 cubic feet of pulpwood and 2.82 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 24.21 net tons of carbon per acre during one rotation (Table 3).

Sugar maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 7). This

optimal management regime will generate the maximum SEV of -$332.76 (Table 15), with a NPW of -$332.76 per acre (Table 11). This financially optimal rotation would produce an estimated 4,098.69 cubic feet of pulpwood and 2.82 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 24.21 net tons of carbon per acre during one rotation (Table 3).

<u>Central States- Sugar maple - Timber Only Rotations (C = $50/ton)</u>

Sugar maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $690.20 (Table 16), with a NPW of $617.24 per acre (Table 12). This means that $690.20 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $617.24 per acre for managing one rotation, or $690.20 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,960.97 cubic feet of pulpwood and 7.83 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 20.38 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Sugar maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$20.71 (Table 16), with a NPW of -$20.46 per acre (Table 12). This financially optimal rotation would produce an estimated 2,960.97 cubic feet of pulpwood and 7.83 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 20.38 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$210.18 (Table 16), with a NPW of -$209.89 per acre (Table 12). This financially optimal rotation would produce an estimated 2,960.97 cubic feet of pulpwood and 7.83 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 20.38 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$287.33 (Table 16),

with a NPW of -$287.28 per acre (Table 12). This financially optimal rotation would produce an estimated 2,943.68 cubic feet of pulpwood and 7.76 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 20.26 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 75 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$325.70 (Table 16), with a NPW of -$325.69 per acre (Table 12). This financially optimal rotation would produce an estimated 2,934.68 cubic feet of pulpwood and 7.76 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 20.26 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$347.20 (Table 16), with a NPW of -$347.20 per acre (Table 12). This financially optimal rotation would produce an estimated 2,610.07 cubic feet of pulpwood and 6.29 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 17.05 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 71 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $1,058.42 (Table 16), with a NPW of $946.53 per acre (Table 12). This financially optimal rotation would produce an estimated 3,519.76 cubic feet of pulpwood and 10.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 26.78 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $119.51 (Table 16), with a NPW of $118.10 per acre (Table 12). This financially optimal rotation would produce an estimated 3,554.91 cubic feet of pulpwood and 9.86 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 26.87 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$135.89 (Table 16), with a NPW of -$135.70 per acre (Table 12). This financially optimal rotation would

produce an estimated 3,554.91 cubic feet of pulpwood and 9.86 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 26.87 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of -$242.00 (Table 16), with a NPW of -$241.96 per acre (Table 12). This financially optimal rotation would produce an estimated 3,570.65 cubic feet of pulpwood and 9.39 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 26.57 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$295.54 (Table 16), with a NPW of -$295.54 per acre (Table 12). This financially optimal rotation would produce an estimated 3,014.86 cubic feet of pulpwood and 8.17 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 22.19 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This

optimal management regime will generate the maximum SEV of -$325.83 (Table 16), with a NPW of -$325.83 per acre (Table 12). This financially optimal rotation would produce an estimated 3,014.86 cubic feet of pulpwood and 8.17 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 22.19 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $1,319.66 (Table 16), with a NPW of $1,180.16 per acre (Table 12). This financially optimal rotation would produce an estimated 3,475.95 cubic feet of pulpwood and 12.70 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.04 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $205.18 (Table 16), with a NPW of $202.76 per acre (Table 12). This financially optimal rotation would produce an estimated 3,475.95 cubic feet of pulpwood and 12.70 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.04 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$90.35 (Table 16), with a NPW of -$90.22 per acre (Table 12). This financially optimal rotation would produce an estimated 3,545.45 cubic feet of pulpwood and 12.14 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.08 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$212.63 (Table 16), with a NPW of -$212.59 per acre (Table 12). This financially optimal rotation would produce an estimated 4,098.69 cubic feet of pulpwood and 2.82 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 24.21 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$274.27 (Table 16), with a NPW of -$274.27 per acre (Table 12). This financially optimal rotation would produce an estimated 4,098.69 cubic feet of pulpwood and 2.82 MBF of sawlogs per acre

from the final harvest (Table 20), and sequester 24.21 net tons of carbon per acre during one rotation (Table 4).

Sugar maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$309.80 (Table 16), with a NPW of -$309.80 per acre (Table 12). This financially optimal rotation would produce an estimated 4,098.69 cubic feet of pulpwood and 2.82 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 24.21 net tons of carbon per acre during one rotation (Table 4).

Species ___sugar maple_________ Region ______Lake States_________________

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 8.30, 9.98, and 10.83 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 25 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183553598 and 0.489476260, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Perala and Alban (1994) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$Y = 0.02953D^{1.826}H^{1.036}*1000$$

where:

Y = component dry-weight (kg.)

D = diameter at breast height (cm.)

H = height (cm.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be \$355/mbf (International 1/4) (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005) and pulpwood price was assumed to be \$17/cord (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005). The price of carbon was assumed to be \$0, \$10, \$37 or \$50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of sugar maple plantations in the Lake States.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$152.60	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]The seedling cost was estimated based on the seedling prices from Minnesota DNR State Forest Nursery (http://www.dnr.state.mn.us/forestry/nurseries/pricelist.html. January 18, 2006) and Lee's Nursery, Inc. (http://www.leenursery.com/Seedling2006Catalog.pdf. January 18, 2006).

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Table 23. Total tons of carbon sequestered per acre for sugar maple plantations in the lake states United States by site index and real alternative rates of return. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	29.19	26.41	23.62	23.62	23.48	23.48
80	32.13	28.40	25.91	25.91	25.91	25.91
90	34.97	32.40	30.19	27.71	27.71	27.71

[1]Base age 50.

Table 24. Total tons of carbon sequestered per acre for sugar maple plantations in the lake states United States by site index and real alternative rates of return. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	29.19	26.41	23.62	23.62	23.48	23.48
80	32.13	28.40	28.40	25.91	25.91	25.91
90	46.52	46.52	40.67	28.23	27.71	27.71

[1]Base age 50.

Table 25. Total tons of carbon sequestered per acre for sugar maple plantations in the lakes states United States by site index and real alternative rates of return. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	29.19	26.41	27.39	24.68	23.94	23.94
80	32.13	30.07	30.07	30.07	27.65	26.09
90	46.52	47.84	41.95	31.92	28.75	27.70

[1]Base age 50.

Table 26. Total tons of carbon sequestered per acre for sugar maple plantations in the lake states United States by site index and real alternative rates of return. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	29.19	26.41	27.39	23.94	23.94	23.94
80	32.13	32.65	30.07	30.19	26.09	26.18
90	46.52	47.84	47.84	41.95	27.70	27.75

[1]Base age 50.

Table 27. Financially optimal thinning and final harvest schedules which maximize soil expectation value for sugar maple plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	31-60-**83**[2] (30%)	<31-60-**69>** (30%)[3]	<31-38-**56**>[4] (30%)	<31-38-**56**> (30%)	<31-37-**56**> (30%)	<31-37-**56**> (30%)
80	31-57-**72** (30%)	<30-55-**61**> (30%)	<30-35-**51**> (30%)	<30-35-**51**> (30%)	<30-35-**51**> (30%)	<30-35-**51**> (30%)
90	30-52-**76** (30%)	<30-52-**65**> (30%)	<30-36-**55**> (30%)	<30-35-**48**> (30%)	<30-35-**48**> (30%)	<30-35-**48**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 28. Financially optimal thinning and final harvest schedules which maximize soil expectation value for sugar maple plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	31-60-**83**[2] (30%)[3]	<31-60-**69**>[4] (30%)	<31-38-**56**> (30%)	<31-38-**56**> (30%)	<31-37-**56**> (30%)	<31-37-**56**> (30%)
80	31-57-**72** (30%)	30-55-**61** (30%)	<30-55-**61**> (30%)	<30-35-**51**> (30%)	<30-35-**51**> (30%)	<30-35-**51**> (30%)
90	30-53-**68** (25%)	30-53-**68** (25%)	<30-53-**59**> (25%)	<30-35-**49**> (30%)	<30-35-**48**> (30%)	<30-35-**48**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 29. Financially optimal thinning and final harvest schedules which maximize soil expectation value for sugar maple plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	31-60-**83**[2] (30%)[3]	31-60-**69** (30%)	42-62-**71** (30%)	<43-**62**>[4] (30%)	<43-59-**64**> (20%)	<43-59-**64**> (20%)
80	31-57-**72** (30%)	39-57-**63** (30%)	39-57-**63** (30%)	39-57-**63** (30%)	<40-**57**> (30%)	<40-**58**> (20%)
90	30-53-**68** (25%)	37-54-**69** (25%)	37-54-**60** (25%)	35-54-**59** (30%)	<37-**54**> (25%)	<40-**55**> (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 30. Financially optimal thinning and final harvest schedules which maximize soil expectation value for sugar maple plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	31-60-**83**[2] (30%)[3]	31-60-**69** (30%)	42-62-**71** (30%)	43-59-**64** (20%)	<43-59-**64**>[4] (20%)	<43-59-**64**> (20%)
80	31-57-**72** (30%)	39-57-**73** (30%)	39-57-**63** (30%)	40-57-**64** (30%)	40-**58** (20%)	<46-**59**> (20%)
90	30-53-**68** (25%)	37-54-**69** (25%)	37-54-**69** (25%)	37-54-60 (25%)	40-**55** (20%)	<42-**55**> (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 31. Net present worth of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$663.96	-$202.14	-$345.94	-$383.43	-$393.80	-$396.54
80	$830.91	-$142.83	-$327.20	-$375.39	-$390.47	-$395.18
90	$1,024.23	-$93.03	-$315.05	-$368.74	-$387.68	-$393.94

[1]Base age 50.

Table 32. Net present worth of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$911.99	-$37.26	-$232.06	-$297.03	-$326.53	-$342.91
80	$1,111.84	$49.07	-$192.80	-$270.66	-$308.03	-$328.93
90	$1,324.14	$134.46	-$155.68	-$251.19	-$294.41	-$318.80

[1]Base age 50.

Table 33. Net present worth of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,582.41	$407.91	$83.28	-$59.80	-$142.49	-$196.65
80	$1,870.34	$575.95	$196.00	$19.38	-$81.72	-$147.91
90	$2,312.53	$805.62	$298.85	$74.97	-$39.11	-$113.76

[1]Base age 50.

Table 34. Net present worth of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,905.21	$622.26	$241.30	$56.96	-$52.79	-$125.81
80	$2,235.55	$850.70	$385.62	$161.87	$28.49	-$60.10
90	$2,788.42	$1,133.94	$525.14	$235.23	$85.62	-$14.22

[1]Base age 50.

Table 35. Soil expectation value of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$759.07	-$209.01	-$351.64	-$385.12	-$394.27	-$396.68
80	$994.96	-$150.12	-$335.00	-$378.05	-$391.33	-$395.45
90	$1,204.08	-$96.90	-$320.64	-$372.23	-$388.79	-$394.35

[1]Base age 50.

Table 36. Soil expectation value of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,043.06	-$38.52	-$235.89	-$298.33	-$326.93	-$343.03
80	$1,331.35	$51.58	-$195.00	-$272.58	-$308.71	-$329.16
90	$1,618.73	$139.26	-$157.74	-$253.35	-$295.33	-$319.13

[1]Base age 50.

Table 37. Soil expectation value of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1,809.83	$421.78	$83.74	-$59.95	-$142.56	-$196.68
80	$2,239.60	$602.48	$197.94	$19.42	-$81.81	-$147.95
90	$2,827.02	$833.00	$302.52	$75.21	-$39.17	-$113.81

[1]Base age 50.

Table 38. Soil expectation value of the financially optimal thinning and final harvest schedules for sugar maple plantations by site index and real alternative rates of return in the lake states United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$2,179.02	$643.40	$242.63	$57.08	-$52.81	-$125.82
80	$2,676.91	$874.34	$389.42	$162.20	$28.52	-$60.11
90	$3,408.79	$1,172.47	$528.49	$235.94	$85.73	-$14.23

[1]Base age 50.

Table 39. Volume removed from the financially optimal schedules for sugar maple plantations by soil productivity and real alternative rates of return in the lake states United States. (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	31-60-**83**[3] (30%)[4]	622.67	0	665.25	2.62	1,386.47	16.61	2,674.39	19.23
	5.00%	31-60-**69** (30%)	622.67	0	665.25	2.62	1,297.79	10.56	2,585.71	13.18
	7.50%	31-38-**56** (30%)	622.67	0	575.00	0	1,771.11	6.99	2,968.78	6.99
	10.00%	31-38-**56** (30%)	622.67	0	575.00	0	1,771.11	6.99	2,968.78	6.99
	12.50%	31-37-**56** (30%)	622.67	0	568.20	0	1,781.03	6.82	2,971.90	6.82
	15.00%	31-37-**56** (30%)	622.67	0	568.20	0	1,781.03	6.82	2,971.90	6.82
80	2.50%	31-57-**72** (30%)	674.84	0	669.68	2.62	1,298.19	15.20	2,642.71	17.82
	5.00%	30-55-**61** (30%)	648.62	0	647.55	2.53	1,538.12	9.52	2,879.29	12.50
	7.50%	30-35-**51** (30%)	648.62	0	650.86	0	1,682.90	6.58	2,982.38	6.58
	10.00%	30-35-**51** (30%)	648.62	0	650.86	0	1,682.90	6.58	2,982.38	6.58
	12.50%	30-35-**51** (30%)	648.62	0	650.86	0	1,682.90	6.58	2,982.38	6.58
	15.00%	30-35-**51** (30%)	648.62	0	650.86	0	1,682.90	6.58	2,982.38	6.58
90	2.50%	30-52-**76** (30%)	806.77	0	745.22	2.44	1,309.01	19.67	2,861.00	22.11
	5.00%	30-52-**65** (30%)	806.77	0	745.22	2.44	1,545.72	14.01	3,097.71	16.45
	7.50%	30-36-**55** (30%)	806.77	0	705.52	0	1,686.23	10.39	3,198.52	10.39
	10.00%	30-35-**48** (30%)	806.77	0	676.90	0	2,044.33	6.18	3,528.00	6.18
	12.50%	30-35-**48** (30%)	806.77	0	676.90	0	2,044.33	6.18	3,528.00	6.18
	15.00%	30-35-**48** (30%)	806.77	0	676.90	0	2,044.33	6.18	3,528.00	6.18

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 40. Volume removed from the financially optimal schedules for sugar maple plantations by soil productivity and real alternative rates of return in the lake states United States. (carbon value = $10/ton)

Site Index[1]	ARR	Schedule	1st thinning		2nd thinning		Final Harvest		Total Volume	
			Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	31-60-**83**[3] (30%)[4]	622.67	0	665.25	2.62	1,386.47	16.61	2,674.39	19.23
	5.00%	31-60-**69** (30%)	622.67	0	665.25	2.62	1,297.79	10.56	2,585.71	13.18
	7.50%	31-38-**56** (30%)	622.67	0	575.00	0	1,771.11	6.99	2,968.78	6.99
	10.00%	31-38-**56** (30%)	622.67	0	575.00	0	1,771.11	6.99	2,968.78	6.99
	12.50%	31-37-**56** (30%)	622.67	0	568.20	0	1,781.03	6.82	2,971.90	6.82
	15.00%	31-37-**56** (30%)	622.67	0	568.20	0	1,781.03	6.82	2,971.90	6.82
80	2.50%	31-57-**72** (30%)	674.84	0	669.68	2.62	1,298.19	15.20	2,642.71	17.82
	5.00%	30-55-**61** (30%)	648.62	0	647.55	2.53	1,538.12	9.52	2,879.29	12.50
	7.50%	30-35-**61** (30%)	648.62	0	647.55	2.53	1,538.12	9.52	2,879.29	12.50
	10.00%	30-35-**51** (30%)	648.62	0	650.86	0	1,682.90	6.58	2,982.38	6.58
	12.50%	30-35-**51** (30%)	648.62	0	650.86	0	1,682.90	6.58	2,982.38	6.58
	15.00%	30-35-**51** (30%)	648.62	0	650.86	0	1,682.90	6.58	2,982.38	6.58
90	2.50%	30-53-**68** (25%)	672.27	0	659.45	2.15	1,739.47	15.82	3,071.19	17.97
	5.00%	30-53-**68** (25%)	672.27	0	659.45	2.15	1,739.47	15.82	3,071.19	17.97
	7.50%	30-53-**59** (25%)	672.27	0	659.45	2.15	1,697.59	10.47	3,029.31	12.62
	10.00%	30-35-**49** (30%)	806.77	0	676.90	0	2,045.21	6.72	3,528.88	6.72
	12.50%	30-35-**48** (30%)	806.77	0	676.90	0	2,044.33	6.18	3,528.00	6.18
	15.00%	30-35-**48** (30%)	806.77	0	676.90	0	2,044.33	6.18	3,528.00	6.18

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 41. Volume removed from the financially optimal schedules for sugar maple plantations by soil productivity and real alternative rates of return in the lake states United States. (carbon value = $37/ton)

Site Index[1]	ARR	Schedule	1st thinning		2nd thinning		Final Harvest		Total Volume	
			Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	31-60-**83**[3] (30%)[4]	622.67	0	665.25	2.62	1,386.47	16.61	2,674.39	19.23
	5.00%	31-60-**69** (30%)	622.67	0	665.25	2.62	1,297.79	10.56	2,585.71	13.18
	7.50%	42-62-**71** (30%)	840.41	0	702.21	2.41	1,290.41	10.49	2,833.03	12.90
	10.00%	43-**62** (30%)	944.40	0	-[5]	-	2,257.35	8.29	3,201.75	8.29
	12.50%	43-59-**64** (20%)	611.20	0	516.20	0.99	1,880.09	7.46	3,007.49	8.45
	15.00%	43-59-**64** (20%)	611.20	0	516.20	0.99	1,880.09	7.46	3,007.49	8.45
80	2.50%	31-57-**72** (30%)	674.84	0	669.68	2.62	1,298.19	15.20	2,642.71	17.82
	5.00%	39-57-**63** (30%)	963.58	0	638.21	2.49	1,589.19	9.83	3,190.98	12.32
	7.50%	39-57-**63** (30%)	963.58	0	638.21	2.49	1,589.19	9.83	3,190.98	12.32
	10.00%	39-57-**63** (30%)	963.58	0	638.21	2.49	1,589.19	9.83	3,190.98	12.32
	12.50%	40-**57** (30%)	991.77	0	-	-	2,152.10	8.44	3,143.87	8.44
	15.00%	40-**58** (20%)	661.05	0	-	-	2,356.23	8.06	3,017.28	8.06
90	2.50%	30-53-**68** (25%)	672.27	0	659.45	2.15	1,739.47	15.82	3,071.19	17.97
	5.00%	37-54-**69** (25%)	813.88	0	658.93	2.15	1,670.24	15.81	3,143.05	17.96
	7.50%	37-54-**60** (25%)	813.88	0	658.93	2.15	1,717.26	10.35	3,190.07	12.50
	10.00%	35-54-**59** (30%)	931.18	0	783.29	2.57	1,597.73	9.86	3,312.20	12.43
	12.50%	37-**54** (25%)	813.88	0	-	-	2,637.86	8.65	3,451.74	8.65
	15.00%	40-**55** (20%)	746.81	0	-	-	2,639.80	8.65	3,386.61	8.65

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 42. Volume removed from the financially optimal schedules for sugar maple plantations by soil productivity and real alternative rates of return in the lake states United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	31-60-**83**[3] (30%)[4]	622.67	0	665.25	2.62	1,386.47	16.61	2,674.39	19.23
	5.00%	31-60-**69** (30%)	622.67	0	665.25	2.62	1,297.79	10.56	2,585.71	13.18
	7.50%	42-62-**71** (30%)	840.41	0	702.21	2.41	1,290.41	10.49	2,833.03	12.90
	10.00%	43-59-**64** (20%)	611.20	0	516.20	0.99	1,880.09	7.46	3,007.49	8.45
	12.50%	43-59-**64** (20%)	611.20	0	516.20	0.99	1,880.09	7.46	3,007.49	8.45
	15.00%	43-59-**64** (20%)	611.20	0	516.20	0.99	1,880.09	7.46	3,007.49	8.45
80	2.50%	31-57-**72** (30%)	674.84	0	669.68	2.62	1,298.19	15.20	2,642.71	17.82
	5.00%	39-57-**73** (30%)	963.58	0	638.21	2.49	1,281.95	15.00	2,883.74	17.49
	7.50%	39-57-**63** (30%)	963.58	0	638.21	2.49	1,589.19	9.83	3,190.98	12.32
	10.00%	40-57-**64** (30%)	991.77	0	645.29	2.52	1,579.22	9.81	3,216.28	12.33
	12.50%	40-**58** (20%)	661.05	0	-[5]	-	2,356.23	8.06	3,017.28	8.06
	15.00%	46-**59** (20%)	705.68	0	-	-	2,222.63	8.66	2,928.31	8.66
90	2.50%	30-53-**68** (25%)	672.27	0	659.45	2.15	1,739.47	15.82	3,071.19	17.97
	5.00%	37-54-**69** (25%)	813.88	0	658.93	2.15	1,670.24	15.81	3,143.05	17.96
	7.50%	37-54-**69** (25%)	813.88	0	658.93	2.15	1,670.24	15.81	3,143.05	17.96
	10.00%	37-54-**60** (25%)	813.88	0	658.93	2.15	1,717.26	10.35	3,190.07	12.50
	12.50%	40-**55** (20%)	746.81	0	-	-	2,639.80	8.65	3,386.61	8.65
	15.0%	42-**55** (20%)	756.75	0	-	-	2,685.36	8.45	3,442.11	8.45

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 43. Financially optimal thinning and final harvest schedules for sugar maple plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	31-60-**83**[2] (30%)	31-60-**83** (30%)	0%	31-60-**83** (30%)	0%	31-60-**83** (30%)	0%
	80	31-57-**72** (30%)	31-57-**72** (30%)	0%	31-57-**72** (30%)	0%	31-57-**72** (30%)	0%
	90	30-52-**76** (30%)	30-52-**76** (30%)	0%	31-53-**77** (30%)	1%	31-53-**77** (30%)	1%
5.00%	70	<31-60-**69**>[3] (30%)[4]	<31-60-**69**> (30%)	0%	31-60-**69** (30%)	0%	31-60-**69** (30%)	0%
	80	<30-55-**61**> (30%)	30-55-**61** (30%)	0%	39-57-**63** (30%)	3%	39-57-**73** (30%)	20%
	90	<30-52-**65**> (30%)	30-52-**65** (30%)	0%	35-54-**67** (30%)	3%	35-54-**67** (30%)	3%
7.50%	70	<31-38-**56**> (30%)	<31-38-**56**> (30%)	0%	42-62-**71** (30%)	27%	42-62-**71** (30%)	27%
	80	<30-35-**51**> (30%)	<30-55-**61**> (30%)	20%	39-57-**63** (30%)	24%	39-57-**63** (30%)	24%
	90	<30-36-**55**> (30%)	<30-52-**57**> (30%)	4%	35-54-**59** (30%)	7%	35-54-**59** (30%)	7%
10.00%	70	<31-38-**56**> (30%)	<31-38-**56**> (30%)	0%	<43-**62**> (30%)	11%	43-59-**64** (20%)	14%
	80	<30-35-**51**> (30%)	<30-35-**51**> (30%)	0%	39-57-**63** (30%)	24%	40-57-**64** (30%)	25%
	90	<30-35-**48**> (30%)	<30-35-**49**> (30%)	2%	35-54-**59** (30%)	23%	38-54-**60** (25%)	25%
12.50%	70	<31-37-**56**> (30%)	<31-37-**56**> (30%)	0%	<43-59-**64**> (20%)	14%	<43-59-**64**> (20%)	14%
	80	<30-35-**51**> (30%)	<30-35-**51**> (30%)	0%	<40-**57**> (30%)	12%	40-**58** (20%)	14%
	90	<30-35-**48**> (30%)	<30-35-**48**> (30%)	0%	<37-**54**> (25%)	13%	40-**55** (20%)	15%
15.00%	70	<31-37-**56**> (30%)	<31-37-**56**> (30%)	0%	<43-59-**64**> (20%)	14%	<43-59-**64**> (20%)	14%
	80	<30-35-**51**> (30%)	<30-35-**51**> (30%)	0%	<40-**58**> (20%)	14%	<46-**59**> (20%)	16%
	90	<30-35-**48**> (30%)	<30-35-**48**> (30%)	0%	<40-**55**> (20%)	15%	<42-**55**> (20%)	15%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning

Table 44. The soil expectation value ($/acre) of the financially optimal rotations for sugar maple plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	759.07	1,043.06	37%	1,809.83	74%	2,179.02	187%
	80	994.96	1,331.35	34%	2,239.60	68%	2,676.91	169%
	90	1,204.08	1,569.26	30%	2,559.33	63%	3,037.21	152%
5.00%	70	-209.01	-38.52		421.78		643.40	
	80	-150.12	51.58		602.48		874.34	
	90	-96.90	128.88		743.10		1,044.74	
7.50%	70	-351.64	-235.89		83.74		242.63	
	80	-335.00	-195.00		197.94		389.42	
	90	-320.64	-161.84		277.96		490.94	
10.00%	70	-385.12	-298.33		-59.95		57.08	
	80	-378.05	-272.58		19.42		162.20	
	90	-372.23	-253.35		75.21		236.06	
12.50%	70	-394.27	-326.93		-142.56		-52.81	
	80	-391.33	-308.71		-81.81		28.52	
	90	-388.79	-295.33		-39.17		85.73	
15.00%	70	-396.68	-343.03		-196.68		-125.82	
	80	-395.45	-329.16		-147.95		-60.11	
	90	-394.35	-319.13		-113.81		-14.23	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

Lake States- Sugar maple - Timber Only Rotations (C = $0/ton)

Sugar maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 31 and 60 (with a 30 percent of basal area removal) and a final harvest at stand age 83 is conducted (Table 27). This optimal management regime will generate the maximum SEV of $759.07 (Table 35), with a NPW of $663.96 per acre (Table 31). This means that $759.07 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $663.96 per acre for managing one rotation, or $759.07 per acre from managing an infinite number of rotations. This financially optimal rotation could produce an estimated 2,674.39 cubic feet of pulpwood and 19.23 MBF of sawlog per acre from the thinning and final harvest (Table 39), and sequester 29.19 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 31 and 60 (with a 30 percent of basal area removal) and a final harvest at stand age 69 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$209.01 (Table 35), with a NPW of -$202.14 per acre (Table 31). This financially optimal rotation could produce an estimated 2,585.71 cubic feet of pulpwood and 13.18 MBF of sawlog per acre

from the thinning and final harvest (Table 39), and sequester 26.41 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 31 and 38 (with a 30 percent of basal area removal) and a final harvest at stand age 56 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$351.64 (Table 35), with a NPW of -$345.94 per acre (Table 31). This financially optimal rotation could produce an estimated 2,968.78 cubic feet of pulpwood and 6.99 MBF of sawlog per acre from the thinning and final harvest (Table 39), and sequester 23.62 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 31 and 38 (with a 30 percent of basal area removal) and a final harvest at stand age 56 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$385.12 (Table 35), with a NPW of -$383.43 per acre (Table 31). This financially optimal rotation could produce an estimated 2,968.78 cubic feet of pulpwood and 6.99 MBF of sawlog per acre from the thinning and final harvest (Table 39), and sequester 23.62 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 31 and 37 (with a 30 percent of

basal area removal) and a final harvest at stand age 56 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$394.27 (Table 35), with a NPW of -$393.80 per acre (Table 31). This financially optimal rotation could produce an estimated 2,971.90 cubic feet of pulpwood and 6.82 MBF of sawlog per acre from the thinning and final harvest (Table 39), and sequester 23.48 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 31 and 37 (with a 30 percent of basal area removal) and a final harvest at stand age 56 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$396.68 (Table 35), with a NPW of -$396.54 per acre (Table 31). This financially optimal rotation could produce an estimated 2,971.90 cubic feet of pulpwood and 6.82 MBF of sawlog per acre from the thinning and final harvest (Table 39), and sequester 23.48 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 31 and 57 (with a 30 percent of basal area removal) and a final harvest at stand age 72 is conducted (Table 27). This optimal management regime will generate the maximum SEV of $994.96 (Table 35), with a NPW of $830.91 per acre (Table 31). This financially optimal rotation could produce an estimated 2,642.71 cubic feet of pulpwood and 17.82 MBF of sawlog per acre

from the thinning and final harvest (Table 39), and sequester 32.13 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 30 and 55 (with a 30 percent of basal area removal) and a final harvest at stand age 61 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$150.12 (Table 35), with a NPW of -$142.83 per acre (Table 31). This financially optimal rotation could produce an estimated 2,879.29 cubic feet of pulpwood and 12.50 MBF of sawlog per acre from the thinning and final harvest (Table 39), and sequester 28.40 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with a 30 percent of basal area removal) and a final harvest at stand age 51 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$335.00 (Table 35), with a NPW of -$327.20 per acre (Table 31). This financially optimal rotation could produce an estimated 2,982.38 cubic feet of pulpwood and 6.58 MBF of sawlog per acre from the thinning and final harvest (Table 39), and sequester 25.91 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with a 30 percent of

basal area removal) and a final harvest at stand age 51 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$378.05 (Table 35), with a NPW of -$375.39 per acre (Table 31). This financially optimal rotation could produce an estimated 2,982.38 cubic feet of pulpwood and 6.85 MBF of sawlog per acre from the thinning and final harvest (Table 39), and sequester 25.91 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with a 30 percent of basal area removal) and a final harvest at stand age 51 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$391.33 (Table 35), with a NPW of -$390.47 per acre (Table 31). This financially optimal rotation could produce an estimated 2,982.38 cubic feet of pulpwood and 6.58 MBF of sawlog per acre from the thinning and final harvest (Table 39), and sequester 25.91 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with a 30 percent of basal area removal) and a final harvest at stand age 51 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$395.45 (Table 35), with a NPW of -$395.18 per acre (Table 31). This financially optimal rotation could produce an estimated 2,982.38 cubic feet of pulpwood and 6.58 MBF of sawlog per acre

from the thinning and final harvest (Table 39), and sequester 25.91 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 30 and 52 (with a 30 percent of basal area removal) and a final harvest at stand age 76 is conducted (Table 27). This optimal management regime will generate the maximum SEV of $1,204.08 (Table 35), with a NPW of $1,024.23 per acre (Table 31). This financially optimal rotation could produce an estimated 2,861.00 cubic feet of pulpwood and 22.11 MBF of sawlog per acre from the thinning and final harvest (Table 39), and sequester 34.97 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 30 and 52 (with a 30 percent of basal area removal) and a final harvest at stand age 65 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$96.90 (Table 35), with a NPW of -$93.03 per acre (Table 31). This financially optimal rotation could produce an estimated 3,097.71 cubic feet of pulpwood and 16.45 MBF of sawlog per acre from the thinning and final harvest (Table 39), and sequester 32.40 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 30 and 36 (with a 30 percent of basal area removal) and a final harvest at stand age 55 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$320.64 (Table 35), with a NPW of -$315.05 per acre (Table 31). This financially optimal rotation could produce an estimated 3,198.52 cubic feet of pulpwood and 10.39 MBF of sawlog per acre from the thinning and final harvest (Table 39), and sequester 30.19 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with a 30 percent of basal area removal) and a final harvest at stand age 48 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$372.23 (Table 35), with a NPW of -$368.74 per acre (Table 31). This financially optimal rotation could produce an estimated 3,528.00 cubic feet of pulpwood and 6.18 MBF of sawlog per acre from the thinning and final harvest (Table 39), and sequester 27.71 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with a 30 percent of basal area removal) and a final harvest at stand age 48 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$388.79 (Table 35), with a NPW of -$387.68 per acre (Table 31). This financially optimal rotation could produce an estimated 3,528.00 cubic feet of pulpwood and 6.18 MBF of sawlog per acre

from the thinning and final harvest (Table 39), and sequester 27.71 tons of carbon per acre during the rotation (Table 23).

Sugar maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with a 30 percent of basal area removal) and a final harvest at stand age 48 is conducted (Table 27). This optimal management regime will generate the maximum SEV of -$394.35 (Table 35), with a NPW of -$393.94 per acre (Table 31). This financially optimal rotation could produce an estimated 3,528.00 cubic feet of pulpwood and 6.18 MBF of sawlog per acre from the thinning and final harvest (Table 39), and sequester 27.71 tons of carbon per acre during the rotation (Table 23).

Lake States- Sugar maple - Timber Plus Carbon Rotations (C = $10/ton)

Sugar maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 31 and 60 (with a 30 percent of basal area removal) and a final harvest at stand age 83 is conducted (Table 28). This optimal management regime will generate the maximum SEV of $1,043.06 (Table 36), with a NPW of $911.99 per acre (Table 32). This means that $1,043.06 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $911.99 per acre for managing one rotation, or $1,043.06 per acre from managing an infinite number of rotations. This financially optimal rotation could produce an estimated 2,674.39 cubic feet of pulpwood and 19.23 MBF of sawlog per acre from the thinning and final harvest (Table 40), and sequester 29.19 tons of carbon per acre during the rotation (Table 24).

Sugar maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 31 and 60 (with a 30 percent of basal area removal) and a final harvest at stand age 69 is conducted (Table 28). This optimal management regime will generate the maximum SEV of -$38.52 (Table 36), with a NPW of -$37.26 per acre (Table 32). This financially optimal rotation could produce an estimated 2,585.71 cubic feet of pulpwood and 13.18 MBF of sawlog per acre from the thinning and final harvest (Table 40), and sequester 26.41 tons of carbon per acre during the rotation (Table 24).

Sugar maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 31 and 38 (with a 30 percent of basal area removal) and a final harvest at stand age 56 is conducted (Table 28). This optimal management regime will generate the maximum SEV of -$235.89 (Table 36), with a NPW of -$232.06 per acre (Table 32). This financially optimal rotation could produce an estimated 2,968.78 cubic feet of pulpwood and 6.99 MBF of sawlog per acre from the thinning and final harvest (Table 40), and sequester 23.62 tons of carbon per acre during the rotation (Table 24).

Sugar maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 31 and 38 (with a 30 percent of basal area removal) and a final harvest at stand age 56 is conducted (Table 28). This optimal management regime will generate the maximum SEV of -$298.33 (Table 36), with a NPW of -$297.03 per acre (Table 32). This financially optimal rotation could produce an estimated 2,968.78 cubic feet of pulpwood and 6.99 MBF of sawlog per acre from the thinning and final harvest (Table 40), and sequester 23.62 tons of carbon per acre during the rotation (Table 24).

Sugar maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 31 and 37 (with a 30 percent of basal area removal) and a final harvest at stand age 56 is conducted (Table 28). This optimal management regime will generate the maximum SEV of -$326.93 (Table 36), with a NPW of -$326.53 per acre (Table 32). This financially optimal rotation could produce an estimated 2,971.90 cubic feet of pulpwood and 6.82 MBF of sawlog per acre from the thinning and final harvest (Table 40), and sequester 23.48 tons of carbon per acre during the rotation (Table 24).

Sugar maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 31 and 37 (with a 30 percent of basal area removal) and a final harvest at stand age 56 is conducted (Table 28). This optimal management regime will generate the maximum SEV of -$343.03 (Table 36), with a NPW of -$342.91 per acre (Table 32). This financially optimal rotation could

produce an estimated 2,971.90 cubic feet of pulpwood and 6.82 MBF of sawlog per acre from the thinning and final harvest (Table 40), and sequester 23.48 tons of carbon per acre during the rotation (Table 24).

Sugar maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 31 and 57 (with a 30 percent of basal area removal) and a final harvest at stand age 72 is conducted (Table 28). This optimal management regime will generate the maximum SEV of $1,331.35 (Table 36), with a NPW of $1,111.84 per acre (Table 32). This financially optimal rotation could produce an estimated 2,642.71 cubic feet of pulpwood and 17.82 MBF of sawlog per acre from the thinning and final harvest (Table 40), and sequester 32.13 tons of carbon per acre during the rotation (Table 24).

Sugar maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 30 and 55 (with a 30 percent of basal area removal) and a final harvest at stand age 61 is conducted (Table 28). This optimal management regime will generate the maximum SEV of $51.58 (Table 36), with a NPW of $49.07 per acre (Table 32). This financially optimal rotation could produce an estimated 2,879.29 cubic feet of pulpwood and 12.50 MBF of sawlog per acre from the thinning and final harvest (Table 40), and sequester 28.40 tons of carbon per acre during the rotation (Table 24).

Sugar maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 30 and 55 (with a 30 percent of basal area removal) and a final harvest at stand age 61 is conducted (Table 28). This optimal management regime will generate the maximum SEV of -$195.00 (Table 36), with a NPW of -$192.80 per acre (Table 32). This financially optimal rotation could produce an estimated 2,879.29 cubic feet of pulpwood and 12.50 MBF of sawlog per acre from the thinning and final harvest (Table 40), and sequester 28.40 tons of carbon per acre during the rotation (Table 24).

Sugar maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with a 30 percent of basal area removal) and a final harvest at stand age 51 is conducted (Table 28). This optimal management regime will generate the maximum SEV of -$272.58 (Table 36), with a NPW of -$270.66 per acre (Table 32). This financially optimal rotation could produce an estimated 2,982.38 cubic feet of pulpwood and 6.58 MBF of sawlog per acre from the thinning and final harvest (Table 40), and sequester 25.91 tons of carbon per acre during the rotation (Table 24).

Sugar maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with a 30 percent of basal area removal) and a final harvest at stand age 51 is conducted (Table 28). This optimal management regime will generate the maximum SEV of -$308.71 (Table 36), with a NPW of -$308.03 per acre (Table 32). This financially optimal rotation could

produce an estimated 2,982.38 cubic feet of pulpwood and 6.58 MBF of sawlog per acre from the thinning and final harvest (Table 40), and sequester 25.91 tons of carbon per acre during the rotation (Table 24).

Sugar maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with a 30 percent of basal area removal) and a final harvest at stand age 51 is conducted (Table 28). This optimal management regime will generate the maximum SEV of -$329.16 (Table 36), with a NPW of -$328.93 per acre (Table 32). This financially optimal rotation could produce an estimated 2,982.38 cubic feet of pulpwood and 6.58 MBF of sawlog per acre from the thinning and final harvest (Table 40), and sequester 25.91 tons of carbon per acre during the rotation (Table 24).

Sugar maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 28). This optimal management regime will generate the maximum SEV of $1,569.26 (Table 36), with a NPW of $1,334.86 per acre (Table 32). This financially optimal rotation would produce an estimated 2,861.00 cubic feet of pulpwood and 22.07 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 34.97 net tons of carbon per acre during one rotation (Table 24).

Sugar maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 28). This optimal management regime will generate the maximum SEV of $128.88 (Table 36), with a NPW of $123.93 per acre (Table 32). This financially optimal rotation would produce an estimated 3,097.71 cubic feet of pulpwood and 16.45 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 32.40 net tons of carbon per acre during one rotation (Table 24).

Sugar maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 28). This optimal management regime will generate the maximum SEV of -$161.84 (Table 36), with a NPW of -$159.40 per acre (Table 32). This financially optimal rotation would produce an estimated 3,015.98 cubic feet of pulpwood and 11.45 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 29.32 net tons of carbon per acre during one rotation (Table 24).

Sugar maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 28). This optimal management regime will generate the maximum SEV of -$253.35 (Table 36), with a NPW of -$251.19 per acre (Table 32). This financially optimal

rotation would produce an estimated 3,528.88 cubic feet of pulpwood and 6.72 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 28.23 net tons of carbon per acre during one rotation (Table 24).

Sugar maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 48 (Table 28). This optimal management regime will generate the maximum SEV of -$295.33 (Table 36), with a NPW of -$294.41 per acre (Table 32). This financially optimal rotation would produce an estimated 3,528.00 cubic feet of pulpwood and 6.18 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 27.71 net tons of carbon per acre during one rotation (Table 24).

Sugar maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 48 (Table 28). This optimal management regime will generate the maximum SEV of -$319.13 (Table 36), with a NPW of -$318.80 per acre (Table 32). This financially optimal rotation would produce an estimated 3,528.00 cubic feet of pulpwood and 6.18 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 27.71 net tons of carbon per acre during one rotation (Table 24).

Lake States- Sugar maple - Timber Plus Carbon Rotations (C = $37/ton)

Sugar maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 31 and 60 (with a 30 percent of basal area removal) and a final harvest at stand age 83 is conducted (Table 29). This optimal management regime will generate the maximum SEV of $1,809.83 (Table 37), with a NPW of $1,582.41 per acre (Table 33). This means that $1,809.83 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,582.41 per acre for managing one rotation, or $1,809.83 per acre from managing an infinite number of rotations. This financially optimal rotation could produce an estimated 2,674.39 cubic feet of pulpwood and 19.23 MBF of sawlog per acre from the thinning and final harvest (Table 41), and sequester 29.19 tons of carbon per acre during the rotation (Table25).

Sugar maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 31 and 60 (with a 30 percent of basal area removal) and a final harvest at stand age 69 is conducted (Table 29). This optimal management regime will generate the maximum SEV of $421.78 (Table 37), with a NPW of $407.91 per acre (Table 33). This financially optimal rotation could produce an estimated 2,585.71 cubic feet of pulpwood and 13.18 MBF of sawlog per acre

from the thinning and final harvest (Table 41), and sequester 26.41 tons of carbon per acre during the rotation (Table 25).

Sugar maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 42 and 62 (with a 30 percent of basal area removal) and a final harvest at stand age 71 is conducted (Table 29). This optimal management regime will generate the maximum SEV of $83.74 (Table 37), with a NPW of $83.28 per acre (Table 33). This financially optimal rotation could produce an estimated 2,833.03 cubic feet of pulpwood and 12.90 MBF of sawlog per acre from the thinning and final harvest (Table 41), and sequester 27.39 tons of carbon per acre during the rotation (Table 25).

Sugar maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning at stand age 43 (with a 30 percent of basal area removal) and a final harvest at stand age 62 is conducted (Table 29). This optimal management regime will generate the maximum SEV of -$59.95 (Table 37), with a NPW of -$59.80 per acre (Table 33). This financially optimal rotation could produce an estimated 3,201.75 cubic feet of pulpwood and 8.29 MBF of sawlog per acre from the thinning and final harvest (Table 41), and sequester 24.68 tons of carbon per acre during the rotation (Table 25).

Sugar maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 43 and 59 (with a 20 percent of

basal area removal) and a final harvest at stand age 64 is conducted (Table 29). This optimal management regime will generate the maximum SEV of -$142.56 (Table 37), with a NPW of -$142.49 per acre (Table 33). This financially optimal rotation could produce an estimated 3,007.49 cubic feet of pulpwood and 8.45 MBF of sawlog per acre from the thinning and final harvest (Table 41), and sequester 23.94 tons of carbon per acre during the rotation (Table 25).

Sugar maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 43 and 59 (with a 20 percent of basal area removal) and a final harvest at stand age 64 is conducted (Table 29). This optimal management regime will generate the maximum SEV of -$196.68 (Table 37), with a NPW of -$196.65 per acre (Table 33). This financially optimal rotation could produce an estimated 3,007.49 cubic feet of pulpwood and 8.45 MBF of sawlog per acre from the thinning and final harvest (Table 41), and sequester 23.94 tons of carbon per acre during the rotation (Table 25).

Sugar maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 31 and 57 (with a 30 percent of basal area removal) and a final harvest at stand age 72 is conducted (Table 29). This optimal management regime will generate the maximum SEV of $2,239.60 (Table 37), with a NPW of $1,870.34 per acre (Table 33). This financially optimal rotation could produce an estimated 2,642.71 cubic feet of pulpwood and 17.82 MBF of sawlog per acre

from the thinning and final harvest (Table 41), and sequester 32.13 tons of carbon per acre during the rotation (Table 25).

Sugar maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 39 and 57 (with a 30 percent of basal area removal) and a final harvest at stand age 63 is conducted (Table 29). This optimal management regime will generate the maximum SEV of $602.48 (Table 37), with a NPW of $575.95 per acre (Table 33). This financially optimal rotation could produce an estimated 3,190.98 cubic feet of pulpwood and 12.32 MBF of sawlog per acre from the thinning and final harvest (Table 41), and sequester 30.07 tons of carbon per acre during the rotation (Table 25).

Sugar maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 39 and 57 (with a 30 percent of basal area removal) and a final harvest at stand age 63 is conducted (Table 29). This optimal management regime will generate the maximum SEV of $197.94 (Table 37), with a NPW of $196.00 per acre (Table 33). This financially optimal rotation could produce an estimated 3,190.98 cubic feet of pulpwood and 12.32 MBF of sawlog per acre from the thinning and final harvest (Table 41), and sequester 30.07 tons of carbon per acre during the rotation (Table 25).

Sugar maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 39 and 57 (with a 30 percent of

basal area removal) and a final harvest at stand age 63 is conducted (Table 29). This optimal management regime will generate the maximum SEV of $19.42 (Table 37), with a NPW of $19.38 per acre (Table 33). This financially optimal rotation could produce an estimated 3,190.98 cubic feet of pulpwood and 12.32 MBF of sawlog per acre from the thinning and final harvest (Table 41), and sequester 30.07 tons of carbon per acre during the rotation (Table 25).

Sugar maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 40 (with a 30 percent of basal area removal) and a final harvest at stand age 57 is conducted (Table 29). This optimal management regime will generate the maximum SEV of -$81.81 (Table 37), with a NPW of -$81.72 per acre (Table 33). This financially optimal rotation could produce an estimated 3,143.87 cubic feet of pulpwood and 8.44 MBF of sawlog per acre from the thinning and final harvest (Table 41), and sequester 27.65 tons of carbon per acre during the rotation (Table 25).

Sugar maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 40 (with a 20 percent of basal area removal) and a final harvest at stand age 58 is conducted (Table 29). This optimal management regime will generate the maximum SEV of -$147.95 (Table 37), with a NPW of -$147.91 per acre (Table 33). This financially optimal rotation could produce an estimated 3,017.28 cubic feet of pulpwood and 8.06 MBF of sawlog per acre from the thinning and final harvest (Table 41), and sequester 26.09 tons of carbon per acre during the rotation (Table 25).

Sugar maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 29). This optimal management regime will generate the maximum SEV of $2,559.33 (Table 37), with a NPW of $2,186.37 per acre (Table 33). This financially optimal rotation would produce an estimated 2,854.30 cubic feet of pulpwood and 22.61 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 35.29 net tons of carbon per acre during one rotation (Table 25).

Sugar maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 29). This optimal management regime will generate the maximum SEV of $743.10 (Table 37), with a NPW of $716.18 per acre (Table 33). This financially optimal rotation would produce an estimated 3,267.91 cubic feet of pulpwood and 17.06 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 34.23 net tons of carbon per acre during one rotation (Table 25).

Sugar maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 54 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 29). This optimal management regime will generate the maximum SEV of $277.96 (Table 37), with a NPW of $274.33 per acre (Table 33). This financially optimal rotation would produce an estimated 3,312.20 cubic feet of pulpwood and 12.43 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 31.92 net tons of carbon per acre during one rotation (Table 25).

Sugar maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 29). This optimal management regime will generate the maximum SEV of $75.21 (Table 37), with a NPW of $74.97 per acre (Table 33). This financially optimal rotation would produce an estimated 3,312.20 cubic feet of pulpwood and 12.43 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 31.92 net tons of carbon per acre during one rotation (Table 25).

Sugar maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 37 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 29). This optimal management regime will generate the maximum SEV of -$39.17 (Table 37), with a NPW of -$39.11 per acre (Table 33). This financially optimal rotation would produce an estimated 3,451.74 cubic feet of pulpwood and 8.65 MBF of sawlogs per acre from the

thinning and final harvest (Table 41), and sequester 28.75 net tons of carbon per acre during one rotation (Table 25).

Sugar maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 40 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 29). This optimal management regime will generate the maximum SEV of -$113.81 (Table 37), with a NPW of -$113.76 per acre (Table 33). This financially optimal rotation would produce an estimated 3,386.61 cubic feet of pulpwood and 8.65 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 27.70 net tons of carbon per acre during one rotation (Table 25).

<u>Lake States- Sugar maple - Timber Plus Carbon Rotations (C = $50/ton)</u>

Sugar maple, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 31 and 60 (with a 30 percent of basal area removal) and a final harvest at stand age 83 is conducted (Table 30). This optimal management regime will generate the maximum SEV of $2,179.02 (Table 38), with a NPW of $1,905.21 per acre (Table 34). This means that $2,179.02 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,905.21 per acre for managing one rotation, or $2,179.02 per acre from managing an infinite number of rotations. This financially optimal rotation could produce an estimated 2,674.39 cubic feet of pulpwood and 19.23 MBF of sawlog per acre from the thinning and final harvest (Table 42), and sequester 29.19 tons of carbon per acre during the rotation (Table 26).

Sugar maple, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 31 and 60 (with a 30 percent of basal area removal) and a final harvest at stand age 69 is conducted (Table 30). This optimal management regime will generate the maximum SEV of $643.40 (Table 38), with a NPW of $622.26 per acre (Table 34). This financially optimal rotation could produce an estimated 2,585.71 cubic feet of pulpwood and 13.18 MBF of sawlog per acre from the thinning and final harvest (Table 42), and sequester 26.41 tons of carbon per acre during the rotation (Table 26).

Sugar maple, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 42 and 62 (with a 30 percent of basal area removal) and a final harvest at stand age 71 is conducted (Table 30). This optimal management regime will generate the maximum SEV of $242.63 (Table 38), with a NPW of $241.30 per acre (Table 34). This financially optimal rotation could produce an estimated 2,833.03 cubic feet of pulpwood and 12.90 MBF of sawlog per acre from the thinning and final harvest (Table 42), and sequester 27.39 tons of carbon per acre during the rotation (Table 26).

Sugar maple, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 43 and 59 (with a 20 percent of basal area removal) and a final harvest at stand age 64 is conducted (Table 30). This optimal management regime will generate the maximum SEV of $57.08 (Table 38), with a NPW of $56.96 per acre (Table 34). This financially optimal rotation could produce an estimated 3,007.49 cubic feet of pulpwood and 8.45 MBF of sawlog per acre from the thinning and final harvest (Table 42), and sequester 23.94 tons of carbon per acre during the rotation (Table 26).

Sugar maple, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 43 and 59 (with a 20 percent of basal area removal) and a final harvest at stand age 64 is conducted (Table 30). This optimal management regime will generate the maximum SEV of -$52.81 (Table 38), with a NPW of -$52.79 per acre (Table 34). This financially optimal rotation could produce an estimated 3,007.49 cubic feet of pulpwood and 8.45 MBF of sawlog per acre from the thinning and final harvest (Table 42), and sequester 23.94 tons of carbon per acre during the rotation (Table 26).

Sugar maple, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 43 and 59 (with a 20 percent of basal area removal) and a final harvest at stand age 64 is conducted (Table 30). This optimal management regime will generate the maximum SEV of -$125.82 (Table 38), with a NPW of -$125.81 per acre (Table 34). This financially optimal rotation could

produce an estimated 3,007.49 cubic feet of pulpwood and 8.45 MBF of sawlog per acre from the thinning and final harvest (Table 42), and sequester 23.94 tons of carbon per acre during the rotation (Table 26).

Sugar maple, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 31 and 57 (with a 30 percent of basal area removal) and a final harvest at stand age 72 is conducted (Table 30). This optimal management regime will generate the maximum SEV of $2,676.91 (Table 38), with a NPW of $2,235.55 per acre (Table 34). This financially optimal rotation could produce an estimated 2,642.71 cubic feet of pulpwood and 17.82 MBF of sawlog per acre from the thinning and final harvest (Table 42), and sequester 32.13 tons of carbon per acre during the rotation (Table 26).

Sugar maple, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 39 and 57 (with a 30 percent of basal area removal) and a final harvest at stand age 73 is conducted (Table 30). This optimal management regime will generate the maximum SEV of $874.34 (Table 38), with a NPW of $850.70 per acre (Table 34). This financially optimal rotation could produce an estimated 2,883.74 cubic feet of pulpwood and 17.49 MBF of sawlog per acre from the thinning and final harvest (Table 42), and sequester 32.65 tons of carbon per acre during the rotation (Table 26).

Sugar maple, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 39 and 57 (with a 30 percent of basal area removal) and a final harvest at stand age 63 is conducted (Table 30). This optimal management regime will generate the maximum SEV of $389.42 (Table 38), with a NPW of $385.62 per acre (Table 34). This financially optimal rotation could produce an estimated 3,190.98 cubic feet of pulpwood and 12.32 MBF of sawlog per acre from the thinning and final harvest (Table 42), and sequester 30.07 tons of carbon per acre during the rotation (Table 26).

Sugar maple, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 40 and 57 (with a 30 percent of basal area removal) and a final harvest at stand age 64 is conducted (Table 30). This optimal management regime will generate the maximum SEV of $162.20 (Table 38), with a NPW of $161.87 per acre (Table 34). This financially optimal rotation could produce an estimated 3,216.28 cubic feet of pulpwood and 12.33 MBF of sawlog per acre from the thinning and final harvest (Table 42), and sequester 30.19 tons of carbon per acre during the rotation (Table 26).

Sugar maple, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 40 (with a 20 percent of basal area removal) and a final harvest at stand age 58 is conducted (Table 30). This optimal management regime will generate the maximum SEV of $28.52 (Table 38), with a NPW of $28.49 per acre (Table 34). This financially optimal rotation could produce an estimated 3,017.28 cubic feet of pulpwood and 8.06 MBF of sawlog per acre from the thinning and final harvest (Table 42), and sequester 26.09 tons of carbon per acre during the rotation (Table 26).

Sugar maple, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 46 (with a 20 percent of basal area removal) and a final harvest at stand age 59 is conducted (Table 30). This optimal management regime will generate the maximum SEV of -$60.11 (Table 38), with a NPW of -$60.10 per acre (Table 34). This financially optimal rotation could produce an estimated 2,928.31 cubic feet of pulpwood and 8.66 MBF of sawlog per acre from the thinning and final harvest (Table 42), and sequester 26.18 tons of carbon per acre during the rotation (Table 26).

Sugar maple, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 31 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 30). This optimal management regime will generate the maximum SEV of $3,037.21 (Table 38), with a NPW of $2,594.61 per acre (Table 34). This financially optimal rotation would produce an estimated 2,854.43 cubic feet of pulpwood and 22.61 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 35.29 net tons of carbon per acre during one rotation (Table 26).

Sugar maple, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 30). This optimal management regime will generate the maximum SEV of $1,044.74 (Table 38), with a NPW of $1,006.88 per acre (Table 34). This financially optimal rotation would produce an estimated 3,267.91 cubic feet of pulpwood and 17.06 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 34.23 net tons of carbon per acre during one rotation (Table 26).

Sugar maple, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 30). This optimal management regime will generate the maximum SEV of $490.94 (Table 38), with a NPW of $484.53 per acre (Table 34). This financially optimal rotation would produce an estimated 3,312.20 cubic feet of pulpwood and 12.43 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 31.92 net tons of carbon per acre during one rotation (Table 26).

Sugar maple, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 54 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 30). This optimal management regime will generate the maximum SEV of $236.06 (Table 38), with a NPW of $235.35 per acre (Table 34). This financially optimal rotation

would produce an estimated 3,168.44 cubic feet of pulpwood and 12.55 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 31.09 net tons of carbon per acre during one rotation (Table 26).

Sugar maple, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 40 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 30). This optimal management regime will generate the maximum SEV of $85.73 (Table 38), with a NPW of $85.62 per acre (Table 34). This financially optimal rotation would produce an estimated 3,386.61 cubic feet of pulpwood and 8.65 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 27.70 net tons of carbon per acre during one rotation (Table 26).

Sugar maple, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 42 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 30). This optimal management regime will generate the maximum SEV of -$14.23 (Table 38), with a NPW of -$14.22 per acre (Table 34). This financially optimal rotation would produce an estimated 3,442.11 cubic feet of pulpwood and 8.45 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 27.75 net tons of carbon per acre during one rotation (Table 26).

Sweetgum - *Liquidambar styraciflua* L.

Biological information

Sweetgum, also called redgum, sapgum, starleaf-gum, or bilstedm is a moderate to rapidly growing tree that is commonly found in the bottomlands of the South, especially in the lower Mississippi Valley. It is one of the most important commercial hardwoods in the Southeast (Silvics manual. USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/liquidambar/styraciflua.htm. July 21, 2006).

Sweetgum ranges south from Connecticut throughout the East to central Florida and eastern Texas; west to Missouri, Arkansas, and Oklahoma, and north to southern Illinois. It also grows in Scattered locations in northwestern and central Mexico (Silvics manual. USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/liquidambar/styraciflua.htm. July 21, 2006) (Fig.1).

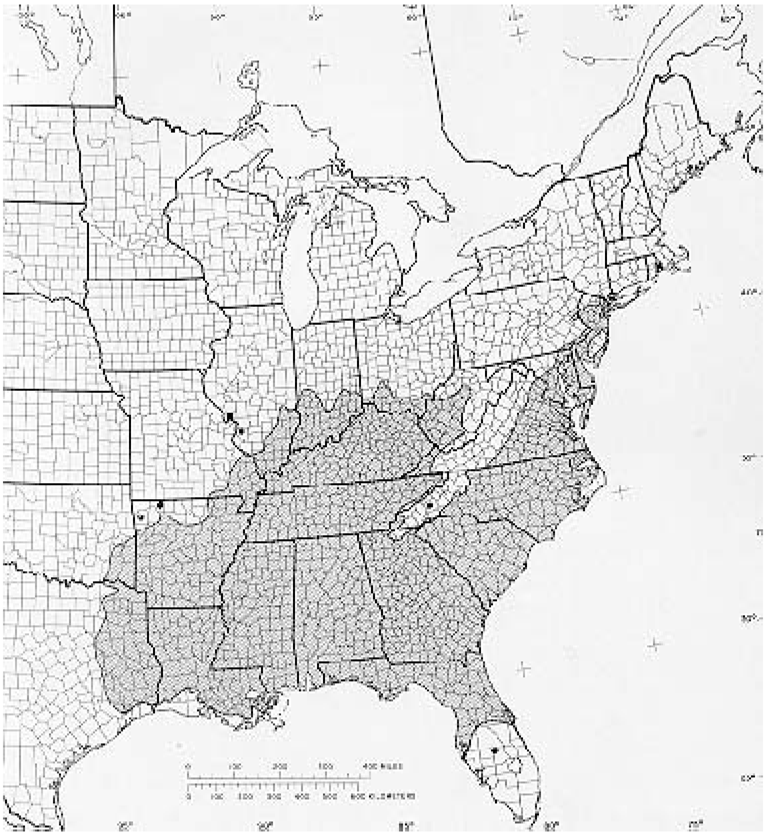

Fig. The native range of sweetgum (Silvics manual. USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/liquidambar/styraciflua.htm. July 21, 2006).

In its early age, sweetgum has a strong excurrent growth habit and long conical crowns that self-prunes readily under forest conditions. However, as the trees mature, sweetgum becomes decurrent, and the crown becomes rounded and wide spreading. The tree stays in the excurrent growth stage longer on moist, fertile bottomlands than on drier, less fertile upland site(Silvics manual. USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/liquidambar/styraciflua.htm. July 21, 2006).

The yield of sweetgum in the Mississippi Delta averages 6,000 to 8,000 mbf/acre. On very good sites, the output can be 15,000 and 20,000 mbf/acre with up to 30,000 to 40,000 mbf/acre on small, selected acres. Sweetgum is often used for lumber, veneer, plywood, railroad ties, fuel, and pulpwood (Silvics manual. USDA Forest Service.
http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/liquidambar/styraciflua.htm. July 21, 2006).

Species___sweetgum__________ Region______South_________________

Site indices 90, 100 and 110 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 9-in. inside bark top diameter for trees with a minimum of 12 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 11-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 20 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 25, 30 and 35% of basal area removal. Three thinning intensities were employed: 25, 30 and 35% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.245225694 and 0.434027778, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Clark et al. (1986) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Yp = 0.08996(D^2H)^{0.95762}$$

$$Ys = 0.09268(D^2)^{1.11308}(H)^{0.95762}$$

where:

Yp = dry-weight (lbs.) of stemwood and bark of trees < 11.0 in. d.b.h

Ys = dry-weight (lbs.) of stemwood and bark of trees $\geq$ 11.0 in d.b.h

D = diameter at breast height (in.)

H = total height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 1.6% and 1.24% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $128.25/mbf (Scribner) (Timber Mart South, Inc. 2000-2005) and pulpwood price was assumed to be $16.44/cord (Timber Mart South Inc. 2000-2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of sweetgum plantations in the South.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$60.00	Only once	Year 0	
Seedlings[b] (436 seedlings/ac)	$152.60	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).

[b]Data from Hans M. Williams, personal communication, Stephen F. Austin State University, December 19, 2006.

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Table 1. Total tons of carbon sequestered per acre for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	28.20	27.12	26.62	26.62	24.33	23.40
100	32.50	31.44	30.20	30.45	29.67	29.67
110	36.62	36.10	34.07	34.07	34.07	33.16

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	28.20	28.20	27.58	26.62	26.62	26.62
100	32.50	32.50	30.92	30.92	30.20	30.45
110	36.62	36.10	36.10	36.10	35.90	34.07

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	30.89	30.89	30.89	30.93	30.93	30.93
100	34.10	34.10	34.10	34.10	34.10	34.10
110	36.62	37.81	37.81	38.70	38.70	39.64

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	30.89	30.80	30.80	30.65	29.93	29.93
100	34.10	34.10	34.29	34.29	34.29	34.29
110	37.81	39.12	39.12	39.12	39.12	39.12

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	<37-53-**60**[2]>[3] (35%)[4]	<37-46-**60**> (35%)	<37-46-**59**> (35%)	<37-46-**59**> (35%)	<35-40-**57**> (35%)	<35-40-**55**> (35%)
100	<37-52-**60>** (35%)	<37-46-**60>** (35%)	<36-43-**59**> (35%)	<36-41-**60**> (35%)	<34-39-**60**> (35%)	<34-39-**60**> (35%)
110	36-49-**60** (35%)	<38-45-**60**> (35%)	<34-39-**60**> (35%)	<34-39-**60**> (35%)	<34-39-**60**> (35%)	<32-37-**60**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	37-53-**60**[2] (35%)[3]	<37-53-**60**>[4] (35%)	<37-49-**60**> (35%)	<37-46-**59**> (35%)	<37-46-**59**> (35%)	<37-46-**59**> (35%)
100	37-52-**60** (35%)	<37-52-**60**> (35%)	<37-46-**59**> (35%)	<37-46-**59**> (35%)	<36-43-**59**> (35%)	<36-41-**60**> (35%)
110	36-49-**60** (35%)	<38-45-**60**> (35%)	<38-45-**60**> (35%)	<38-45-**60**> (35%)	<36-46-**60**> (35%)	<34-39-**60**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return: 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	48-**60**[2] (25%)[3]	43-**60** (25%)	<43-**60**>[4] (25%)	<43-55-**60**> (25%)	<43-55-**60**> (25%)	<43-55-**60**> (25%)
100	45-54-**60** (30%)	45-54-**60** (30%)	<45-54-**60**> (30%)	<45-54-**60**> (30%)	<45-54-**60**> (30%)	<45-54-**60**> (30%)
110	36-49-**60** (35%)	41-47-**60** (30%)	<41-47-**60**> (30%)	<43-48-**60**> (25%)	<43-48-**60**> (25%)	<43-55-**60**> (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	48-**60**[2] (25%)[3]	49-**60** (25%)	<49-**60**>[4] (25%)	<51-**60**> (25%)	<**60**> (0%)	<**60**> (0%)
100	45-54-**60** (30%)	45-54-**60** (30%)	**60** (0%)	<**60**> (0%)	<**60**> (0%)	<**60**> (0%)
110	41-47-**60** (30%)	54-**60** (25%)	54-**60** (25%)	<54-**60**> (25%)	<54-**60**> (25%)	<54-**60**> (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	-$123.12	-$328.13	-$379.39	-$393.44	-$396.83	-$397.53
100	-$37.00	-$304.26	-$372.00	-$390.89	-$395.95	-$397.21
110	$94.39	-$270.56	-$363.31	-$387.81	-$394.83	-$396.74

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$45.07	-$226.97	-$315.34	-$349.34	-$365.18	-$373.66
100	$158.54	-$186.27	-$296.22	-$338.55	-$357.88	-$368.23
110	$315.48	-$134.76	-$274.90	-$327.17	-$350.51	-$362.72

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$533.71	$63.29	-$132.83	-$226.86	-$277.72	-$308.03
100	$693.55	$144.50	-$83.77	-$193.52	-$253.19	-$288.98
110	$912.42	$236.30	-$32.30	-$159.33	-$228.16	-$269.50

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$772.98	$205.52	-$43.56	-$167.07	-$235.20	-$276.24
100	$961.54	$307.19	$20.81	-$122.40	-$202.13	-$250.51
110	$1,200.02	$419.51	$88.34	-$76.67	-$168.43	-$224.22

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	-$158.20	-$345.76	-$384.40	-$394.74	-$397.26	-$397.69
100	-$47.54	-$320.60	-$376.91	-$392.06	-$396.25	-$397.29
110	$121.28	-$285.10	-$367.77	-$388.97	-$395.13	-$396.82

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$57.91	-$239.16	-$319.21	-$350.49	-$365.49	-$373.74
100	$203.71	-$196.27	-$300.14	-$339.66	-$358.19	-$368.30
110	$405.36	-$142.00	-$278.28	-$328.15	-$350.77	-$362.79

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$685.77	$66.69	-$134.46	-$227.54	-$277.93	-$308.09
100	$891.15	$152.26	-$84.80	-$194.10	-$253.39	-$289.04
110	$1,172.39	$249.00	-$32.70	-$159.81	-$228.33	-$269.55

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for sweetgum plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$993.22	$216.56	-$44.09	-$167.57	-$235.38	-$276.29
100	$1,235.50	$323.69	$21.06	-$122.77	-$202.28	-$250.56
110	$1,541.93	$442.05	$89.42	-$76.90	-$168.56	-$224.27

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for sweetgum plantations by soil productivity and real alternative rates of return in the southern United States). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	37-53-**60**[3] (35%)[4]	699.48	0	1,073.14	0	2,517.99	0.73	4,290.61	0.73
	5.0%	37-46-**60** (35%)	699.48	0	809.99	0	2,583.37	0.76	4,092.84	0.76
	7.5%	37-46-**59** (35%)	699.48	0	809.99	0	2,498.65	0.72	4,008.12	0.72
	10.0%	37-46-**59** (35%)	699.48	0	809.99	0	2,498.65	0.72	4,008.12	0.72
	12.5%	35-40-**57** (35%)	567.14	0	606.75	0	2,527.65	0	3,701.54	0
	15.0%	35-40-**55** (35%)	567.14	0	606.75	0	2,352.46	0	3,526.35	0
100	2.5%	37-52-**60** (35%)	847.88	0	1,194.42	0	2,755.12	1.53	4,797.42	1.53
	5.0%	37-46-**60** (35%)	847.88	0	936.36	0	2,793.08	1.63	4,577.32	1.63
	7.5%	36-43-**59** (35%)	801.11	0	821.42	0	2,770.80	1.52	4,393.33	1.52
	10.0%	36-41-**60** (35%)	801.11	0	747.12	0	2,887.48	1.52	4,435.71	1.52
	12.5%	34-39-**60** (35%)	625.90	0	677.78	0	2,919.32	1.52	4,223.00	1.52
	15.0%	34-39-**60** (35%)	625.90	0	677.78	0	2,919.32	1.52	4,223.00	1.52
110	2.5%	36-49-**60** (35%)	937.51	0	1,218.33	0	2,877.43	3.19	5,033.27	3.19
	5.0%	38-45-**60** (35%)	1,046.24	0	1,024.38	0	2,867.98	3.20	4,938.60	3.20
	7.5%	34-39-**60** (35%)	774.43	0	780.66	0	2,968.82	3.23	4,523.91	3.23
	10.0%	34-39-**60** (35%)	774.43	0	780.66	0	2,968.82	3.23	4,523.91	3.23
	12.5%	34-39-**60** (35%)	774.43	0	780.66	0	2,968.82	3.23	4,523.91	3.23
	15.0%	32-37-**60** (35%)	564.05	0	703.21	0	3,002.48	3.26	4,269.74	3.26

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 18. Volume removed from the financially optimal schedules for sweetgum plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	37-53-**60**[3] (35%)[4]	699.48	0	1,073.14	0	2,517.99	0.73	4,290.61	0.73
	5.0%	37-53-**60** (35%)	699.48	0	1,073.14	0	2,517.99	0.73	4,290.61	0.73
	7.5%	37-49-**60** (35%)	699.48	0	920.83	0	2,555.26	0.76	4,175.57	0.76
	10.0%	37-46-**59** (35%)	699.48	0	809.99	0	2,498.65	0.72	4,008.01	0.72
	12.5%	37-46-**59** (35%)	699.48	0	809.99	0	2,498.65	0.72	4,008.01	0.72
	15.0%	37-46-**59** (35%)	699.48	0	809.99	0	2,498.65	0.72	4,008.01	0.72
100	2.5%	37-52-**60** (35%)	847.88	0	1,194.42	0	2,755.12	1.53	4,797.42	1.53
	5.0%	37-52-**60** (35%)	847.88	0	1,194.42	0	2,755.12	1.53	4,797.42	1.53
	7.5%	37-46-**59** (35%)	847.88	0	936.26	0	2,707.73	1.56	4,491.87	1.56
	10.0%	37-46-**59** (35%)	847.88	0	936.26	0	2,707.73	1.56	4,491.87	1.56
	12.5%	36-43-**59** (35%)	801.11	0	821.42	0	2,770.80	1.52	4,393.33	1.52
	15.0%	36-41-**60** (35%)	801.11	0	747.12	0	2,887.48	1.52	4,435.71	1.52
110	2.5%	36-49-**60** (35%)	937.51	0	1,218.33	0	2,877.43	3.19	5,033.27	3.19
	5.0%	38-45-**60** (35%)	1,046.24	0	1,024.38	0	2,867.98	3.20	4,938.60	3.20
	7.5%	38-45-**60** (35%)	1,046.24	0	1,024.38	0	2,867.98	3.20	4,938.60	3.20
	10.0%	38-45-**60** (35%)	1,046.24	0	1,024.38	0	2,867.98	3.20	4,938.60	3.20
	12.5%	38-46-**60** (35%)	1,046.24	0	1,081.41	0	2,874.54	3.24	5,002.19	3.24
	15.0%	34-39-**60** (35%)	774.43	0	780.66	0	2,968.82	3.23	4,523.91	3.23

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 19. Volume removed from the financially optimal schedules for sweetgum plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	48-**60**[3] (25%)[4]	831.04	0	-[5]	-	4,118.53	0	4,949.57	0
	5.0%	43-**60** (25%)	700.95	0	-	-	4,247.47	0	4,948.42	0
	7.5%	43-**60** (25%)	700.95	0	-	-	4,247.47	0	4,948.42	0
	10.0%	43-55-**60** (25%)	700.95	0	896.30	0	3,342.21	0	4,939.46	0
	12.5%	43-55-**60** (25%)	700.95	0	896.30	0	3,342.21	0	4,939.46	0
	15.0%	43-55-**60** (25%)	700.95	0	896.30	0	3,342.21	0	4,939.46	0
100	2.5%	45-54-**60** (30%)	1,033.62	0	1,097.38	0	3,120.62	0.77	5,251.62	0.77
	5.0%	45-54-**60** (30%)	1,033.62	0	1,097.38	0	3,120.62	0.77	5,251.62	0.77
	7.5%	45-54-**60** (30%)	1,033.62	0	1,097.38	0	3,120.62	0.77	5,251.62	0.77
	10.0%	45-54-**60** (30%)	1,033.62	0	1,097.38	0	3,120.62	0.77	5,251.62	0.77
	12.5%	45-54-**60** (30%)	1,033.62	0	1,097.38	0	3,120.62	0.77	5,251.62	0.77
	15.0%	45-54-**60** (30%)	1,033.62	0	1,097.38	0	3,120.62	0.77	5,251.62	0.77
110	2.5%	36-49-**60** (35%)	937.51	0	1,218.33	0	2,877.43	3.19	5,033.27	3.19
	5.0%	41-47-**60** (30%)	1,017.51	0	993.67	0	3,421.57	2.35	5,432.75	2.35
	7.5%	41-47-**60** (30%)	1,017.51	0	993.67	0	3,421.57	2.35	5,432.75	2.35
	10.0%	43-48-**60** (25%)	904.11	0	898.38	0	3,971.59	1.56	5,774.08	1.56
	12.5%	43-48-**60** (25%)	904.11	0	898.38	0	3,971.59	1.56	5,774.08	1.56
	15.0%	43-55-**60** (25%)	904.11	0	1,147.67	0	4,056.98	0.78	6,108.76	0.78

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indiates no operation conducted

Table 20. Volume removed from the financially optimal schedules for sweetgum plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	48-**60**[3] (25%)[4]	831.04	0	-[5]	-	4,118.53	0	4,949.57	0
	5.0%	49-**60** (25%)	857.83	0	-	-	4,094.55	0	4,952.38	0
	7.5%	49-**60** (25%)	857.83	0	-	-	4,094.55	0	4,952.38	0
	10.0%	51-**60** (25%)	912.08	0	-	-	4,094.55	0	5,006.63	0
	12.5%	**60** (0%)	-	0	-	-	4,011.51	0	4,829.48	0
	15.0%	**60** (0%)	-	0	-	-	4,829.48	0	4,829.48	0
100	2.5%	45-54-**60** (30%)	1,033.62	0	1097.38	0	3,120.02	0.77	5,251.02	0.77
	5.0%	45-54-**60** (30%)	1,033.62	0	1097.38	0	3,120.02	0.77	5,251.02	0.77
	7.5%	**60** (0%)	-	0	-	-	5,502.61	0	5,502.61	0
	10.0%	**60** (0%)	-	0	-	-	5,502.61	0	5,502.61	0
	12.5%	**60** (0%)	-	0	-	-	5,502.61	0	5,502.61	0
	15.0%	**60** (0%)	-	0	-	-	5,502.61	0	5,502.61	0
110	2.5%	41-47-**60** (30%)	1,017.51	0	993.67	0	3,421.57	2.35	5,432.75	2.35
	5.0%	54-**60** (25%)	1,265.07	0	-	-	4,804.26	0.77	6,069.33	0.77
	7.5%	54-**60** (25%)	1,265.07	0	-	-	4,804.26	0.77	6,069.33	0.77
	10.0%	54-**60** (25%)	1,265.07	0	-	-	4,804.26	0.77	6,069.33	0.77
	12.5%	54-**60** (25%)	1,265.07	0	-	-	4,804.26	0.77	6,069.33	0.77
	15.0%	54-**60** (25%)	1,265.07	0	-	-	4,804.26	0.77	6,069.33	0.77

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted

Table 21. Financially optimal thinning and final harvest schedules for sweetgum plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	90	<37-53-**60**[2]>[3] (35%)[4]	37-53-**60** (35%)	0%	48-**60** (25%)	0%	48-**60** (25%)	0%
	100	<37-52-**60**> (35%)	37-52-**60** (35%)	0%	45-54-**60** (30%)	0%	45-54-**60** (30%)	0%
	110	36-49-**60** (35%)	36-49-**60** (35%)	0%	36-49-**60** (35%)	0%	41-47-**60** (30%)	0%
5.00%	90	<37-46-**60**> (35%)	<37-53-**60**> (35%)	0%	43-**60** (25%)	0%	49-**60** (25%)	0%
	100	<37-46-**60**> (35%)	<37-52-**60**> (35%)	0%	45-54-**60** (30%)	0%	45-54-**60** (30%)	0%
	110	<38-45-**60**> (35%)	<38-45-**60**> (35%)	0%	41-47-**60** (30%)	0%	54-**60** (25%)	0%
7.50%	90	<37-46-**59**> (35%)	<37-49-**60**> (35%)	2%	<43-**60**> (25%)	2%	<49-**60**> (25%)	2%
	100	<36-43-**59**> (35%)	<37-46-**59**> (35%)	0%	<45-54-**60**> (30%)	2%	**60**	2%
	110	<34-39-**60**> (35%)	<38-45-**60**> (35%)	0%	<41-47-**60**> (30%)	0%	54-**60** (25%)	0%
10.00%	90	<37-46-**59**> (35%)	<37-46-**59**> (35%)	0%	<43-55-**60**> (25%)	2%	<51-**60**> (25%)	2%
	100	<36-41-**60**> (35%)	<37-46-**59**> (35%)	-2%	<45-54-**60**> (30%)	0%	<**60**>	0%
	110	<34-39-**60**> (35%)	<38-45-**60**> (35%)	0%	<43-48-**60**> (25%)	0%	<54-**60**> (25%)	0%
12.50%	90	<35-40-**57**> (35%)	<37-46-**59**> (35%)	4%	<43-55-**60**> (25%)	5%	<**60**>	5%
	100	<34-39-**60**> (35%)	<36-43-**59**> (35%)	-2%	<45-54-**60**> (30%)	0%	<**60**>	0%
	110	<34-39-**60**> (35%)	<36-46-**60**> (35%)	0%	<43-48-**60**> (25%)	0%	<54-**60**> (25%)	0%
15.00%	90	<35-40-**55**> (35%)	<37-46-**59**> (35%)	7%	<43-55-**60**> (25%)	9%	<**60**>	9%
	100	<34-39-**60**> (35%)	<36-41-**60**> (35%)	0%	<45-54-**60**> (30%)	0%	<**60**>	0%
	110	<32-37-**60**> (35%)	<34-39-**60**> (35%)	0%	<43-55-**60**> (25%)	0%	<54-**60**> (25%)	0%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.
[4] Number in parentheses indicates the percentage of basal area removed during thinning.

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for sweetgum plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	90	-158.20	57.91		685.77		993.22	
	100	-47.54	203.71		891.15		1,235.50	
	110	121.28	405.36	234%	1,172.39	867%	1,541.93	1171%
5.00%	90	-345.76	-239.16		66.69		216.56	
	100	-320.60	-196.27		152.26		323.69	
	110	-285.10	-142.00		249.00		442.05	
7.50%	90	-384.40	-319.21		-134.46		-44.09	
	100	-376.91	-300.14		-84.80		21.06	
	110	-367.77	-278.28		-32.70		89.42	
10.00%	90	-394.74	-350.49		-227.54		-167.57	
	100	-392.06	-339.66		-194.10		-122.77	
	110	-388.97	-328.15		-159.81		-76.90	
12.50%	90	-397.26	-365.49		-277.93		-235.38	
	100	-396.25	-358.19		-253.39		-202.28	
	110	-395.13	-350.77		-228.33		-168.56	
15.00%	90	-397.69	-373.74		-308.09		-276.29	
	100	-397.29	-368.30		-289.04		-250.56	
	110	-396.82	-362.79		-269.55		-224.27	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

Southern- Sweetgum - Timber Only Rotations (C = $0/ton)

Sweetgum, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 53 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$158.20 (Table 13), with a NPW of -$123.12 per acre (Table 9). This means that -$158.20 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$123.12 per acre for managing one rotation, or -$158.20 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 4,290.61 cubic feet of pulpwood and 0.73 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 28.20 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Sweetgum, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 46 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$345.76 (Table 13), with a NPW of -$328.13 per acre (Table 9). This financially optimal rotation would

produce an estimated 4,092.84 cubic feet of pulpwood and 0.76 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 27.12 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 46 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 5). This optimal management regime will generate the maximum SEV of -$384.40 (Table 13), with a NPW of -$379.39 per acre (Table 9). This financially optimal rotation would produce an estimated 4,008.12 cubic feet of pulpwood and 0.72 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 26.62 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 46 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 5). This optimal management regime will generate the maximum SEV of -$394.74 (Table 13), with a NPW of -$393.44 per acre (Table 9). This financially optimal rotation would produce an estimated 4,008.12 cubic feet of pulpwood and 0.72 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 26.62 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 40 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 5). This optimal management regime will generate the maximum SEV of -$397.26 (Table 13), with a NPW of -$396.83 per acre (Table 9). This financially optimal rotation would produce an estimated 3,701.54 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 24.33 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 40 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 5). This optimal management regime will generate the maximum SEV of -$397.69 (Table 13), with a NPW of -$397.53 per acre (Table 9). This financially optimal rotation would produce an estimated 3,526.35 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.40 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 52 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$47.54 (Table 13), with a NPW of -$37.00 per acre (Table 9). This financially optimal rotation would

produce an estimated 4,797.42 cubic feet of pulpwood and 1.53 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 32.50 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 46 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$320.60 (Table 13), with a NPW of -$304.26 per acre (Table 9). This financially optimal rotation would produce an estimated 4,577.32 cubic feet of pulpwood and 1.63 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 31.44 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 43 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 5). This optimal management regime will generate the maximum SEV of -$376.91 (Table 13), with a NPW of -$372.00 per acre (Table 9). This financially optimal rotation would produce an estimated 4,393.33 cubic feet of pulpwood and 1.52 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 30.20 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 41 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$392.06 (Table 13), with a NPW of -$390.89 per acre (Table 9). This financially optimal rotation would produce an estimated 4,435.71 cubic feet of pulpwood and 1.52 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 30.45 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 39 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$396.25 (Table 13), with a NPW of -$395.95 per acre (Table 9). This financially optimal rotation would produce an estimated 4,223.00 cubic feet of pulpwood and 1.52 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 29.67 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 39 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$397.29 (Table 13), with a NPW of -$397.21 per acre (Table 9). This financially optimal rotation would

produce an estimated 4,223.00 cubic feet of pulpwood and 1.52 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 29.67 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 49 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of $121.28 (Table 13), with a NPW of $94.39 per acre (Table 9). This financially optimal rotation would produce an estimated 5,033.27 cubic feet of pulpwood and 3.19 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 36.62 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 45 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$285.10 (Table 13), with a NPW of -$270.56 per acre (Table 9). This financially optimal rotation would produce an estimated 4,938.60 cubic feet of pulpwood and 3.20 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 36.10 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 39 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$367.77 (Table 13), with a NPW of -$363.31 per acre (Table 9). This financially optimal rotation would produce an estimated 4,523.91 cubic feet of pulpwood and 3.23 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 34.07 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 39 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$388.97 (Table 13), with a NPW of -$387.81 per acre (Table 9). This financially optimal rotation would produce an estimated 4,523.91 cubic feet of pulpwood and 3.23 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 34.07 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 39 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$395.13 (Table 13), with a NPW of -$394.83 per acre (Table 9). This financially optimal rotation would

produce an estimated 4,523.91 cubic feet of pulpwood and 3.23 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 34.07 net tons of carbon per acre during one rotation (Table 1).

Sweetgum, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 37 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of -$396.82 (Table 13), with a NPW of -$396.74 per acre (Table 9). This financially optimal rotation would produce an estimated 4,269.74 cubic feet of pulpwood and 3.26 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 33.16 net tons of carbon per acre during one rotation (Table 1).

<u>Southern- Sweetgum - Timber + Carbon Rotations (C = $10/ton)</u>

Sweetgum, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 53 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of $57.91 (Table 14), with a NPW of $45.07 per acre (Table 10). This means that $57.91 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $45.07 per acre for managing one rotation, or $57.91 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 4,290.61 cubic feet of pulpwood and 0.73 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 28.20 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Sweetgum, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 53 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$239.16 (Table 14), with a NPW of -$226.97 per acre (Table 10). This financially optimal rotation would produce an estimated 4,290.61 cubic feet of pulpwood and 0.73 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 28.20 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 49 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$319.21 (Table 14), with a NPW of -$315.34 per acre (Table 10). This financially optimal rotation would produce an estimated 4,175.57 cubic feet of pulpwood and 0.76 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 27.58 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 46 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 6). This optimal management regime will generate the maximum SEV of -$350.49 (Table 14), with a NPW of -$349.34 per acre (Table 10). This financially optimal rotation would produce an estimated 4,008.01 cubic feet of pulpwood and 0.72 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.62 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 46 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 6). This optimal management regime will generate the maximum SEV of -$365.49 (Table 14), with a NPW of -$365.18 per acre (Table 10). This financially optimal rotation would produce an estimated 4,008.01 cubic feet of pulpwood and 0.72 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.62 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 46 (with 35

percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 6). This optimal management regime will generate the maximum SEV of -$373.74 (Table 14), with a NPW of -$373.66 per acre (Table 10). This financially optimal rotation would produce an estimated 4,008.01 cubic feet of pulpwood and 0.72 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.62 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 52 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of $203.71 (Table 14), with a NPW of $158.54 per acre (Table 10). This financially optimal rotation would produce an estimated 4,797.42 cubic feet of pulpwood and 1.53 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 32.50 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 52 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$196.27 (Table 14), with a NPW of -$186.27 per acre (Table 10). This financially optimal rotation would produce an estimated 4,797.42 cubic feet of pulpwood and 1.53 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 32.50 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 46 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 6). This optimal management regime will generate the maximum SEV of -$300.14 (Table 14), with a NPW of -$296.22 per acre (Table 10). This financially optimal rotation would produce an estimated 4,491.87 cubic feet of pulpwood and 1.56 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 30.92 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 46 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 6). This optimal management regime will generate the maximum SEV of -$339.66 (Table 14), with a NPW of -$338.55 per acre (Table 10). This financially optimal rotation would produce an estimated 4,491.87 cubic feet of pulpwood and 1.56 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 30.92 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 43 (with 35

percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 6). This optimal management regime will generate the maximum SEV of -$358.19 (Table 14), with a NPW of -$357.88 per acre (Table 10). This financially optimal rotation would produce an estimated 4,393.33 cubic feet of pulpwood and 1.52 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 30.20 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 41 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$368.30 (Table 14), with a NPW of -$368.23 per acre (Table 10). This financially optimal rotation would produce an estimated 4,435.71 cubic feet of pulpwood and 1.52 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 30.45 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 49 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of $405.36 (Table 14), with a NPW of $315.48 per acre (Table 10). This financially optimal rotation would produce an estimated 5,033.27 cubic feet of pulpwood and 3.19 MBF of sawlogs per acre

from the thinning and final harvest (Table 18), and sequester 36.62 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 45 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$142.00 (Table 14), with a NPW of -$134.76 per acre (Table 10). This financially optimal rotation could produce an estimated 4,938.60 cubic feet of pulpwood and 3.20 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 36.10 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 45 (with 35 percent of basal area removed) and a final harvest in conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$278.28 (Table 14), with a NPW of -$274.90 per acre (Table 10). This financially optimal rotation would produce an estimated 4,938.60 cubic feet of pulpwood and 3.20 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 36.10 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 45 (with 35

percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$328.15 (Table 14), with a NPW of -$327.17 per acre (Table 10). This financially optimal rotation would produce an estimated 4,938.60 cubic feet of pulpwood and 3.20 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 36.10 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 46 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$350.77 (Table 14), with a NPW of -$350.51 per acre (Table 10). This financially optimal rotation would produce an estimated 5,002.19 cubic feet of pulpwood and 3.24 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 35.90 net tons of carbon per acre during one rotation (Table 2).

Sweetgum, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 39 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of -$362.79 (Table 14), with a NPW of -$362.72 per acre (Table 10). This financially optimal rotation would produce an estimated 4,523.91 cubic feet of pulpwood and 3.23 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 34.07 net tons of carbon per acre during one rotation (Table 2).

<u>Southern- Sweetgum - Timber + Carbon Rotations (C = $37/ton)</u>

Sweetgum, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 48 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $685.77 (Table 15), with a NPW of $533.71 per acre (Table 11). This means that $685.77 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $533.71 per acre for managing one rotation, or $685.77 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 4,949.57 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 30.89 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Sweetgum, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 43 (with 25 percent of

basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $66.69 (Table 15), with a NPW of $63.29 per acre (Table 11). This financially optimal rotation would produce an estimated 4,948.42 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 30.89 net tons of carbon per acre during one rotation (Table 3).

Sweetgum, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 43 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$134.46 (Table 15), with a NPW of -$132.83 per acre (Table 11). This financially optimal rotation would produce an estimated 4,948.42 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 30.89 net tons of carbon per acre during one rotation (Table 3).

Sweetgum, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 55 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$227.54 (Table 15), with a NPW of -$226.86 per acre (Table 11). This financially optimal rotation would produce an estimated 4,939.46 cubic feet of pulpwood and 0.00 MBF of sawlogs

per acre from the thinning and final harvest (Table 19), and sequester 30.93 net tons of carbon per acre during one rotation (Table 3).

Sweetgum, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 55 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$277.93 (Table 15), with a NPW of -$277.72 per acre (Table 11). This financially optimal rotation would produce an estimated 4,939.46 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 30.93 tons of carbon per acre during the rotation (Table 3).

Sweetgum, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 55 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$308.09 (Table 15), with a NPW of -$308.03 per acre (Table 11). This financially optimal rotation would produce an estimated 4,939.46 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 30.93 tons of carbon per acre during the rotation (Table 3).

Sweetgum, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 54 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $891.15 (Table 15), with a NPW of $693.55 per acre (Table 11). This financially optimal rotation would produce an estimated 5,251.62 cubic feet of pulpwood and 0.77 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 34.10 net tons of carbon per acre during one rotation (Table 3).

Sweetgum, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $152.26 (Table 15), with a NPW of $144.50 per acre (Table 11). This financially optimal rotation would produce an estimated 5,251.62 cubic feet of pulpwood and 0.77 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 34.10 net tons of carbon per acre during one rotation (Table 3).

Sweetgum, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$84.80 (Table 15), with a NPW of -$83.77 per acre (Table 11). This financially optimal rotation would produce an estimated 5,251.62 cubic feet of pulpwood and 0.77 MBF of sawlogs per acre

from the thinning and final harvest (Table 19), and sequester 34.10 net tons of carbon per acre during one rotation (Table 3).

Sweetgum, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$227.54 (Table 15), with a NPW of -$226.86 per acre (Table 11). This financially optimal rotation would produce an estimated 5,251.62 cubic feet of pulpwood and 0.77 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 34.10 net tons of carbon per acre during one rotation (Table 3).

Sweetgum, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$277.93 (Table 15), with a NPW of -$277.72 per acre (Table 11). This financially optimal rotation would produce an estimated 5,251.62 cubic feet of pulpwood and 0.77 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 34.10 net tons of carbon per acre during one rotation (Table 3).

Sweetgum, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 54 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$289.04 (Table 15), with a NPW of -$288.98 per acre (Table 11). This financially optimal rotation would produce an estimated 5,251.62 cubic feet of pulpwood and 0.77 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 34.10 net tons of carbon per acre during one rotation (Table 3).

Sweetgum, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 49 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 50 (Table 7). This optimal management regime will generate the maximum SEV of $1,172.39 (Table 15), with a NPW of $912.42 per acre (Table 11). This financially optimal rotation would produce an estimated 5,033.27 cubic feet of pulpwood and 3.19 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 36.62 net tons of carbon per acre during one rotation (Table 3).

Sweetgum, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $249.00 (Table 15), with a NPW of $236.30 per acre (Table 11). This financially optimal rotation would produce an estimated 5,432.75 cubic feet of pulpwood and 2.35 MBF of sawlogs per acre

from the thinning and final harvest (Table 19), and sequester 37.81 net tons of carbon per acre during one rotation (Table 3).

Sweetgum, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$32.70 (Table 15), with a NPW of -$32.30 per acre (Table 11). This financially optimal rotation would produce an estimated 5,432.75 cubic feet of pulpwood and 2.35 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 37.81 net tons of carbon per acre during one rotation (Table 3).

Sweetgum, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 48 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$159.81 (Table 15), with a NPW of -$159.33 per acre (Table 11). This financially optimal rotation would produce an estimated 5,774.08 cubic feet of pulpwood and 1.56 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 38.70 net tons of carbon per acre during one rotation (Table 3).

Sweetgum, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 48 (with 25

percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$228.33 (Table 15), with a NPW of -$228.16 per acre (Table 11). This financially optimal rotation would produce an estimated 5,774.08 cubic feet of pulpwood and 1.56 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 38.70 tons of carbon per acre during one rotation (Table 3).

Sweetgum, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 55 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of -$269.55 (Table 15), with a NPW of -$269.50 per acre (Table 11). This financially optimal rotation would produce an estimated 6,108.76 cubic feet of pulpwood and 0.78 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 39.64 net tons of carbon per acre during one rotation (Table 3).

Southern- Sweetgum - Timber + Carbon Rotations (C = $50/ton)

Sweetgum, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 48 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $993.22 (Table 16), with a NPW of $772.98 per acre (Table 12). This means that $993.22 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $772.98 per acre for managing one rotation, or $993.22 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 4,949.57 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 30.89 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Sweetgum, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 49 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $216.56 (Table 16), with a NPW of $205.52 per acre (Table 12). This financially optimal rotation would produce an estimated 4,952.38 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 30.80 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 49 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This

optimal management regime will generate the maximum SEV of -$44.09 (Table 16), with a NPW of -$43.56 per acre (Table 12). This financially optimal rotation would produce an estimated 4,952.38 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 30.80 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 51 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$167.56 (Table 16), with a NPW of -$167.07 per acre (Table 12). This financially optimal rotation would produce an estimated 5,006.63 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 30.65 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$235.38 (Table 16), with a NPW of -$235.20 per acre (Table 12). This financially optimal rotation would produce an estimated 4,829.48 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 29.93 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$276.29 (Table 16), with a NPW of -$276.24 per acre (Table 12). This financially optimal rotation would produce an estimated 4,829.48 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 29.93 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $1,235.50 (Table 16), with a NPW of $961.54 per acre (Table 12). This financially optimal rotation would produce an estimated 5,251.02 cubic feet of pulpwood and 0.77 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 34.10 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $323.69 (Table 16), with a NPW of $307.19 per acre (Table 12). This financially optimal rotation would produce an estimated 5,251.02 cubic feet of pulpwood and 0.77 MBF of sawlogs per acre

from the thinning and final harvest (Table 20), and sequester 34.10 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $21.06 (Table 16), with a NPW of $20.81 per acre (Table 12). This financially optimal rotation would produce an estimated 5,502.61 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 34.29 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$122.77 (Table 16), with a NPW of -$122.40 per acre (Table 12). This financially optimal rotation would produce an estimated 5,502.61 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 34.29 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$202.28 (Table 16), with a NPW of -$202.13 per acre (Table 12). This financially optimal rotation would

produce an estimated 5,502.61 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 34.29 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$250.56 (Table 16), with a NPW of -$250.51 per acre (Table 12). This financially optimal rotation would produce an estimated 5,502.61 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 34.29 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $1,5041.93 (Table 16), with a NPW of $1,200.02 per acre (Table 12). This financially optimal rotation would produce an estimated 5,432.75 cubic feet of pulpwood and 2.35 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 37.81 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 54 (with 25 percent of

basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $442.05 (Table 16), with a NPW of $419.51 per acre (Table 12). This financially optimal rotation would produce an estimated 6,069.33 cubic feet of pulpwood and 0.77 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 39.12 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 54 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $89.42 (Table 16), with a NPW of $88.34 per acre (Table 12). This financially optimal rotation would produce an estimated 6,069.33 cubic feet of pulpwood and 0.77 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 39.12 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 54 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$76.90 (Table 16), with a NPW of -$76.67 per acre (Table 12). This financially optimal rotation would produce an estimated 6,069.33 cubic feet of pulpwood and 0.77 MBF of sawlogs per acre from the

thinning and final harvest (Table 20), and sequester 39.12 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 54 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$168.56 (Table 16), with a NPW of -$168.43 per acre (Table 12). This financially optimal rotation would produce an estimated 6,069.33 cubic feet of pulpwood and 0.77 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 39.12 net tons of carbon per acre during one rotation (Table 4).

Sweetgum, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 54 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of -$224.27 (Table 16), with a NPW of -$224.22 per acre (Table 12). This financially optimal rotation would produce an estimated 6,069.33 cubic feet of pulpwood and 0.77 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 39.12 net tons of carbon per acre during one rotation (Table 4).

Water oak (*Quercus nigra*)

Biological Information

Water oak is commonly found along southeastern watercourses and lowlands. The native range extends from southern New Jersey west to southeastern Oklahoma and East Texas, and south to southern Florida (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/quercus/nigra.htm. June 27, 2006) (Fig. 1).

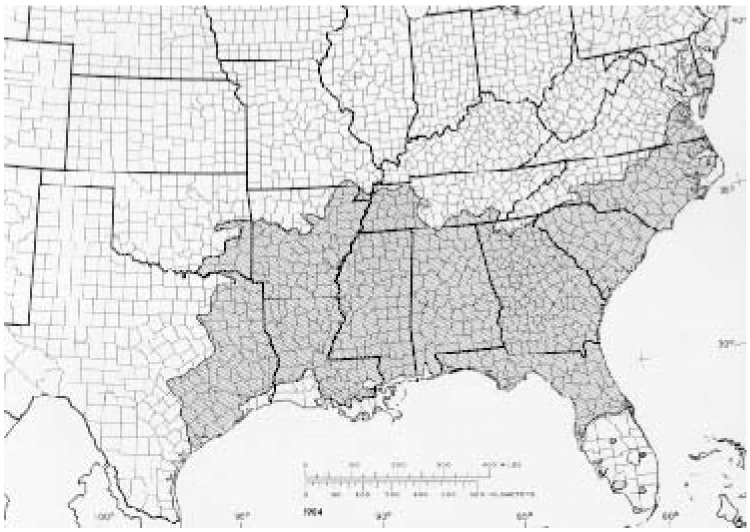

Fig. 1. The native range of water oak (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/quercus/nigra.htm. June 27, 2006)

At maturity water oak reaches heights of 125 feet and on good sites can produce 6 to 12 inches of dbh growth in 10 years. Site indexes range from 60 to 110 feet on a base age 50 curve. Red alder is classified as intolerant of shade and competition, and does not compete well with other species (USDA Forest Service.

http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/quercus/rubra.htm. June 27, 2006).

Water oak is used for timber, fuel, wildlife habitat, and environmental forestry. It is widely planted in the south as a shade tree. Veneer from white oak has been successfully used as plywood for fruit and vegetable containers (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/quercus/rubra.htm. June 27, 2006).

Species ___water oak__________ Region______South_________________

Site indices 90, 100 and 110 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 9-in. inside bark top diameter for trees with a minimum of 12 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 11-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 20 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 25, 30 and 35% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.245225694 and 0.434027778, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Clark et al. (1985) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Yp = 0.16345(D^2H)^{0.93819}$$

$$Ys = 0.23237(D^2)^{0.86484}(H)^{0.93819}$$

where:

Yp = dry-weight (lbs.) of stemwood and bark of trees < 11.0 in. d.b.h

Ys = dry-weight (lbs.) of stemwood and bark of trees $\geq$ 11.0 in d.b.h

D = diameter at breast height (in.)

H = total height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 1.6% and 1.24% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $210/mbf (Scribner) (Timber Mart South, Inc. 2000-2005) and pulpwood price was assumed to be $16.44/cord (Timber Mart South, Inc. 2000-2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of water oak plantations in the South.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$60.00	Only once	Year 0	
Seedlings[b] (436 seedlings/ac)	$130.80	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).

[b]Data from Hans M. Williams, personal communication, Stephen F. Austin State University, December 19, 2006.

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Table 1. Total tons of carbon sequestered per acre for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	52.97	52.97	50.66	48.42	48.42	48.42
100	61.27	61.11	54.20	52.97	52.76	51.23
110	69.29	67.97	61.98	55.54	55.54	55.54

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	52.97	52.97	55.81	51.42	51.42	50.69
100	61.27	61.11	61.58	54.78	53.74	51.95
110	69.29	67.97	65.66	60.81	60.81	56.87

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	56.23	57.74	57.74	57.38	57.38	57.38
100	63.82	64.26	62.81	61.38	61.38	61.14
110	69.29	71.15	68.26	66.50	68.42	68.42

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	57.74	57.74	57.38	57.38	56.52	56.38
100	64.26	64.26	62.81	62.44	64.31	64.31
110	69.29	71.15	68.26	68.42	68.42	71.05

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	29-35-**60**[2] (30%)[3]	29-35-**60** (30%)	<31-36-**58**>[4](35%)	<29-34-**57**>(35%)	<29-34-**57**>(35%)	<29-34-**57**>(35%)
100	27-33-**60** (25%)	28-34-**59** (25%)	<27-32-**54**>(35%)	<26-36-**52**>(35%)	<28-33-**52**>(35%)	<26-31-**52**>(35%)
110	25-**60** (30%)	27-**58** (35%)	<25-30-**52**>(30%)	<24-29-**49**>(35%)	<24-29-**49**>(35%)	<24-29-**49**>(35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	29-35-**60**[2] (30%)[3]	29-35-**60** (30%)	<34-41-**59**> (30%)	<32-37-**58**> (35%)	<32-37-**58**> (35%)	<32-38-**57**> (35%)
100	27-33-**60** (25%)	28-34-**59** (25%)	<31-39-**56**> (30%)	<28-36-**53**> (35%)	<28-36-**52**> (35%)	<28-34-**51**> (35%)
110	25-**60** (30%)	27-**58** (35%)	29-36-**52** (30%)	<27-35-**50**> (35%)	<27-35-**50**> (35%)	<25-31-**49**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	33-41-**60**[2] (30%)[3]	35-45-**60** (30%)	35-45-**60** (30%)	<38-47-**60**> (30%)	<38-47-**60**> (30%)	<38-47-**60**> (30%)
100	30-38-**60** (25%)	31-39-**60** (25%)	33-40-**58** (25%)	34-43-**55** (30%)	<34-43-**55**> (30%)	<37-45-**55**> (30%)
110	25-**60** (30%)	28-**60** (25%)	30-37-**55** (25%)	29-38-**52** (30%)	<39-44-**54**> (25%)	<39-44-**54**> (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	35-45-**60**[2] (30%)[3]	35-45-**60** (30%)	38-47-**60** (30%)	38-47-**60** (30%)	<44-50-**60**> (30%)	<45-53-**60**> (30%)
100	31-39-**60** (25%)	31-39-**60** (25%)	33-40-**58** (25%)	37-42-**57** (25%)	<53-**60**> (35%)	<53-**60**> (35%)
110	25-**60** (30%)	28-**60** (25%)	30-37-**55** (25%)	39-44-**54** (25%)	39-44-**54** (25%)	<52-**58**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$1,714.96	$132.36	-$243.95	-$337.49	-$363.74	-$371.58
100	$2,161.24	$240.41	-$199.77	-$319.30	-$356.23	-$368.38
110	$2,689.05	$359.36	-$150.66	-$297.71	-$346.18	-$363.52

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,026.65	$316.86	-$127.71	-$262.70	-$311.83	-$333.85
100	$2,542.81	$473.42	-$57.92	-$224.95	-$288.87	-$318.35
110	$3,143.56	$639.19	$19.73	-$182.60	-$262.86	-$300.71

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,874.11	$839.60	$197.12	-$50.00	-$165.41	-$228.52
100	$3,594.94	$1,123.45	$344.59	$43.89	-$99.80	-$179.67
110	$4,370.74	$1,417.22	$503.75	$148.40	-$25.65	-$123.42

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$3,304.64	$1,096.29	$355.68	$53.88	-$94.10	-$177.21
100	$4,111.22	$1,437.39	$541.93	$175.71	-$7.15	-$111.82
110	$4,961.60	$1,796.92	$741.09	$311.55	$91.78	-$36.36

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,203.59	$139.47	-$247.42	-$338.84	-$364.13	-$371.69
100	$2,777.02	$254.01	-$203.58	-$321.36	-$356.92	-$368.60
110	$3,455.21	$380.76	-$154.00	-$300.27	-$347.14	-$363.85

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,604.08	$333.88	-$129.39	-$263.65	-$312.13	-$333.95
100	$3,267.30	$500.20	-$58.87	-$226.27	-$289.43	-$318.58
110	$4,039.22	$677.26	$20.17	-$184.02	-$263.51	-$300.98

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$3,692.99	$884.71	$199.54	-$50.15	-$165.54	-$228.57
100	$4,619.20	$1,183.81	$349.50	$44.10	-$99.94	-$179.75
110	$5,616.04	$1,493.36	$512.68	$149.36	-$25.69	-$123.48

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for water oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$4,246.19	$1,155.18	$360.05	$54.04	-$94.17	-$177.24
100	$5,282.58	$1,514.61	$549.64	$176.41	-$7.15	-$111.84
110	$6,375.25	$1,893.46	$754.23	$313.21	$91.92	-$36.37

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for water oak plantations by soil productivity and real alternative rates of return in the southern United States). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	29-35-**60**[3] (30%)[4]	621.60	0	702.54	0	1,345.60	17.45	2,669.74	17.45
	5.0%	29-35-**60** (30%)	621.60	0	702.54	0	1,345.60	17.45	2,669.74	17.45
	7.5%	31-36-**58**> (35%)	846.70	0	811.72	0	1,143.08	15.32	2,801.50	15.32
	10.0%	29-34-**57** (35%)	727.63	0	716.53	0	1,290.08	14.23	2,734.24	14.23
	12.5%	29-34-**57** (35%)	727.63	0	716.53	0	1,290.08	14.23	2,734.24	14.23
	15.0%	29-34-**57** (35%)	727.63	0	716.53	0	1,290.08	14.23	2,734.24	14.23
100	2.5%	27-33-**60** (25%)	570.69	0	697.37	0	1,461.20	21.42	2,729.26	21.42
	5.0%	28-34-**59** (25%)	621.23	0	742.82	0	1,494.89	20.64	2,858.94	20.64
	7.5%	27-32-**54** (35%)	805.17	0	810.74	0	1,240.49	16.29	2,856.40	16.29
	10.0%	26-36-**52** (35%)	676.09	0	1,507.18	0	1,274.17	14.56	3,457.44	14.56
	12.5%	28-33-**52** (35%)	875.21	0	864.06	0	1,414.79	13.93	3,154.06	13.93
	15.0%	26-31-**52** (35%)	676.09	0	759.03	0	1,633.43	13.29	3,068.55	13.29
110	2.5%	25-**60** (30%)	740.97	0	-[5]	-	1,826.77	26.32	2,567.74	26.32
	5.0%	27-**58** (35%)	1,022.27	0	-	-	1,751.86	24.29	2,774.13	24.29
	7.5%	25-30-**52** (30%)	740.97	0	806.13	0	1,528.17	18.99	3,075.27	18.99
	10.0%	24-29-**49** (35%)	791.30	0	828.22	0	1,467.07	15.19	3,086.59	15.19
	12.5%	24-29-**49** (35%)	791.30	0	828.22	0	1,467.07	15.19	3,086.59	15.19
	15.0%	24-29-**49** (35%)	791.30	0	828.22	0	1,467.07	15.19	3,086.59	15.19

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 18. Volume removed from the financially optimal schedules for water oak plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	29-35-**60**[3] (30%)[4]	621.60	0	702.54	0	1,345.60	17.45	2,669.74	17.45
	5.0%	29-35-**60** (30%)	621.60	0	702.54	0	1,345.60	17.45	2,669.74	17.45
	7.5%	34-41-**59** (30%)	882.97	0	963.58	0	1,445.16	16.01	3,291.71	16.01
	10.0%	32-37-**58** (35%)	908.54	0	856.92	0	1,316.35	15.15	3,081.81	15.15
	12.5%	32-37-**58** (35%)	908.54	0	856.92	0	1,136.35	15.15	2,901.81	15.15
	15.0%	32-38-**57** (35%)	908.54	0	910.27	0	1,362.38	13.41	3,181.19	13.41
100	2.5%	27-33-**60** (25%)	570.69	0	697.37	0	1,461.20	21.42	2,729.26	21.42
	5.0%	28-34-**59** (25%)	621.23	0	742.82	0	1,494.89	20.64	2,858.94	20.64
	7.5%	31-39-**56** (30%)	923.41	0	1,094.42	0	1,411.56	17.86	3,429.39	17.86
	10.0%	28-36-**53** (35%)	875.21	0	1,046.12	0	1,245.43	15.09	3,166.76	15.09
	12.5%	28-36-**52** (35%)	875.21	0	1,046.12	0	1,389.39	13.77	3,310.72	13.77
	15.0%	28-34-**51** (35%)	875.21	0	922.61	0	1,586.51	12.41	3,384.33	12.41
110	2.5%	25-**60** (30%)	740.97	0	-[5]	-	1,826.77	26.32	2,567.74	26.32
	5.0%	27-**58** (35%)	1,022.27	0	-	-	1,751.86	24.94	2,774.13	24.94
	7.5%	29-36-**52** (30%)	993.35	0	1,134.50	0	1,531.83	18.26	3,659.68	18.26
	10.0%	27-35-**50** (35%)	1,022.27	0	1,211.28	0	1,325.09	15.90	3,558.64	15.90
	12.5%	27-35-**50** (35%)	1,022.27	0	1,211.28	0	1,325.09	15.90	3,558.64	15.90
	15.0%	25-31-**49** (35%)	866.72	0	949.95	0	1,445.69	15.08	3,262.36	15.08

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for water oak plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	33-41-**60**[3] (30%)[4]	831.78	0	973.57	0	1,422.08	16.30	3,227.43	16.30
	5.0%	35-45-**60** (30%)	925.90	0	1,148.87	0	1,420.54	16.22	3,495.31	16.22
	7.5%	35-45-**60** (30%)	925.90	0	1,148.87	0	1,420.54	16.22	3,495.31	16.22
	10.0%	38-47-**60** (30%)	1,055.94	0	1,198.46	0	1,259.66	16.00	3,514.06	16.00
	12.5%	38-47-**60** (30%)	1,055.94	0	1,198.46	0	1,259.66	16.00	3,514.06	16.00
	15.0%	38-47-**60** (30%)	1,055.94	0	1,198.46	0	1,259.66	16.00	3,514.06	16.00
100	2.5%	30-38-**60** (25%)	719.30	0	923.93	0	1,496.52	20.92	3,139.75	20.92
	5.0%	31-39-**60** (25%)	767.75	0	964.27	0	1,466.56	20.81	3,198.58	20.81
	7.5%	33-40-**58** (25%)	846.41	0	980.94	0	1,506.36	19.21	3,333.71	19.21
	10.0%	34-43-**55** (30%)	1,067.75	0	1,265.29	0	1,393.54	16.30	3,726.58	16.30
	12.5%	34-43-**55** (30%)	1,067.75	0	1,265.29	0	1,393.54	16.30	3,726.58	16.30
	15.0%	37-45-**55** (30%)	1,219.11	0	1,317.15	0	1,335.03	15.57	3,871.29	15.57
110	2.5%	25-**60** (30%)	740.97	0	-[5]	-	1,826.77	26.32	2,567.74	26.32
	5.0%	28-**60** (25%)	779.51	0	-	-	2,183.57	25.40	2,963.08	25.40
	7.5%	30-37-**55** (25%)	870.02	0	1,033.83	0	1,594.93	20.71	3,498.78	20.71
	10.0%	29-38-**52** (30%)	993.35	0	1,263.93	0	1,536.27	18.12	3,793.55	18.12
	12.5%	39-44-**54** (25%)	1,292.94	0	1,222.82	0	1,515.65	18.38	4,031.41	18.38
	15.0%	39-44-**54** (25%)	1,292.94	0	1,222.82	0	1,515.65	18.38	4,031.41	18.38

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for water oak plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	35-45-**60**[3] (30%)[4]	925.90	0	1148.87	0	1,420.54	16.22	3,495.31	16.22
	5.0%	35-45-**60** (30%)	925.90	0	1148.87	0	1,420.54	16.22	3,495.31	16.22
	7.5%	38-47-**60** (30%)	1,055.94	0	1198.46	0	1,259.66	16.00	3,514.06	16.00
	10.0%	38-47-**60** (30%)	1,055.94	0	1198.46	0	1,259.66	16.00	3,514.06	16.00
	12.5%	44-50-**60** (30%)	1,319.93	0	1232.84	0	1,254.37	14.15	3,807.14	14.15
	15.0%	45-53-**60** (30%)	1,363.66	0	1340.43	0	1,271.34	13.33	3,975.43	13.33
100	2.5%	31-39-**60** (25%)	767.75	0	964.27	0	1,466.56	20.81	3,198.58	20.81
	5.0%	31-39-**60** (25%)	767.75	0	964.27	0	1,466.56	20.81	3,198.58	20.81
	7.5%	33-40-**58** (25%)	846.41	0	980.94	0	1,506.36	19.21	3,333.71	19.21
	10.0%	37-42-**57** (25%)	1,012.61	0	1011.29	0	1,545.50	17.87	3,569.40	17.87
	12.5%	53-**60** (35%)	2,343.95	0	-[5]	-	1,487.64	18.12	3,831.59	18.12
	15.0%	53-**60** (35%)	2,343.95	0	-	-	1,487.64	18.12	3,831.59	18.12
110	2.5%	25-**60** (30%)	740.97	0	-	-	1,826.77	26.32	2,567.74	26.32
	5.0%	28-**60** (25%)	779.51	0	-	-	2,183.57	25.40	2,963.08	25.40
	7.5%	30-37-**55** (25%)	870.02	0	1033.83	0	1,594.93	20.71	3,498.78	20.71
	10.0%	39-44-**54** (25%)	1,292.94	0	1222.82	0	1,515.65	18.38	4,031.41	18.38
	12.5%	39-44-**54** (25%)	1,292.94	0	1222.82	0	1,515.65	18.38	4,031.41	18.38
	15.0%	52-**58** (30%)	2,271.06	0	-	-	1,688.42	20.55	3,959.48	20.55

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted

Table 21. Financially optimal thinning and final harvest schedules for water oak plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	90	29-35-**60**[2] (30%)[3]	29-35-**60** (30%)	0%	33-41-**60** (30%)	0%	35-45-**60** (30%)	0%
	100	27-33-**60** (25%)	27-33-**60** (25%)	0%	30-38-**60** (25%)	0%	31-39-**60** (25%)	0%
	110	25-**60** (30%)	25-**60** (30%)	0%	25-**60** (30%)	0%	25-**60** (30%)	0%
5.00%	90	29-35-**60** (30%)	29-35-**60** (30%)	0%	35-45-**60** (30%)	0%	35-45-**60** (30%)	0%
	100	28-34-**59** (25%)	28-34-**59** (25%)	0%	31-39-**60** (25%)	2%	31-39-**60** (25%)	2%
	110	27-**58** (35%)	27-**58** (35%)	0%	28-**60** (25%)	3%	28-**60** (25%)	3%
7.50%	90	<31-36-**58**>[4](35%)	<34-41-**59**> (30%)	2%	35-45-**60** (30%)	3%	38-47-**60** (30%)	3%
	100	<27-32-**54**> (35%)	<31-39-**56**> (30%)	4%	33-40-**58** (25%)	7%	33-40-**58** (25%)	7%
	110	<25-30-**52**> (30%)	29-36-**52** (30%)	0%	30-37-**55** (25%)	6%	30-37-**55** (25%)	6%
10.00%	90	<29-34-**57**> (35%)	<32-37-**58**> (35%)	2%	<38-47-**60**> (30%)	5%	38-47-**60** (30%)	5%
	100	<26-36-**52**> (35%)	<28-36-**53**> (35%)	2%	34-43-**55** (30%)	6%	37-42-**57** (25%)	10%
	110	<24-29-**49**> (35%)	<27-35-**50**> (35%)	2%	29-38-**52** (30%)	6%	39-44-**54** (25%)	10%
12.50%	90	<29-34-**57**> (35%)	<32-37-**58**> (35%)	2%	<38-47-**60**> (30%)	5%	<44-50-**60**> (30%)	5%
	100	<28-33-**52**> (35%)	<28-36-**52**> (35%)	0%	<34-43-**55>** (30%)	6%	<53-**60**> (35%)	15%
	110	<24-29-**49**> (35%)	<27-35-**50**> (35%)	2%	<39-44-**54>** (25%)	10%	39-44-**54** (25%)	10%
15.00%	90	<29-34-**57**> (35%)	<32-38-**57**> (35%)	0%	<38-47-**60**> (30%)	5%	<45-53-**60**> (30%)	5%
	100	<26-31-**52**> (35%)	<28-34-**51**> (35%)	-2%	<37-45-**55>** (30%)	6%	<53-**60**> (35%)	15%
	110	<24-29-**49**> (35%)	<25-31-**49**> (35%)	0%	<39-44-**54>** (25%)	10%	<52-**58**> (30%)	18%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning
[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for water oak plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	90	2,203.59	2,604.08	18%	3,692.99	68%	4,246.19	93%
	100	2,777.02	3,267.30	18%	4,619.20	66%	5,282.58	90%
	110	3,455.21	4,039.22	17%	5,616.04	63%	6,375.25	85%
5.00%	90	139.47	333.88	139%	884.71	534%	1,155.18	728%
	100	254.01	500.20	97%	1,183.81	366%	1,514.61	496%
	110	380.76	677.26	78%	1,493.36	292%	1,893.46	397%
7.50%	90	-247.42	-129.39		199.54		360.05	
	100	-203.58	-58.87		349.50		549.64	
	110	-154.00	20.17		512.68		754.23	
10.00%	90	-338.84	-263.65		-50.15		54.04	
	100	-321.36	-226.27		44.10		176.41	
	110	-300.27	-184.02		149.36		313.21	
12.50%	90	-364.13	-312.13		-165.54		-94.17	
	100	-356.92	-289.43		-99.94		-7.15	
	110	-347.14	-263.51		-25.69		91.92	
15.00%	90	-371.69	-333.95		-228.57		-177.24	
	100	-368.60	-318.58		-179.75		-111.84	
	110	-363.85	-300.98		-123.48		-36.37	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

Southern- Water oak - Timber Only Rotations (C = $0/ton)

Water oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 29 and 35 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $2,203.59 (Table 13), with a NPW of $1,714.96 per acre (Table 9). This means that $2,203.59 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,714.96 per acre for managing one rotation, or $2,203.59 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 2,669.74 cubic feet of pulpwood and 17.45 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 52.95 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Water oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 29 and 35 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $139.47 (Table 13), with a NPW of $132.36 per acre (Table 9). This financially optimal rotation could

produce an estimated 2,669.74 cubic feet of pulpwood and 17.45 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 52.95 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 31 and 36 (with 35 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$247.42 (Table 13), with a NPW of -$243.95 per acre (Table 9). This financially optimal rotation could produce an estimated 2,801.50 cubic feet of pulpwood and 15.32 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 50.66 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 29 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$338.84 (Table 13), with a NPW of -$337.49 per acre (Table 9). This financially optimal rotation could produce an estimated 2,734.24 cubic feet of pulpwood and 14.23 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 48.42 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 29 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$364.13 (Table 13), with a NPW of -$363.74 per acre (Table 9). This financially optimal rotation could produce an estimated 2,734.24 cubic feet of pulpwood and 14.23 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 48.42 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 29 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$371.69 (Table 13), with a NPW of -$371.58 per acre (Table 9). This financially optimal rotation could produce an estimated 2,734.24 cubic feet of pulpwood and 14.23 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 48.42 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 27 and 33 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $2,777.02 (Table 13), with a NPW of $2,161.24 per acre (Table 9). This financially optimal rotation could

produce an estimated 2,729.26 cubic feet of pulpwood and 21.42 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 61.27 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 28 and 34 (with 25 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $254.01 (Table 13), with a NPW of $240.41 per acre (Table 9). This financially optimal rotation could produce an estimated 2,858.94 cubic feet of pulpwood and 20.64 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 61.11 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 27 and 32 (with 35 percent of basal area removed) and a final harvest at stand age 54 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$203.58 (Table 13), with a NPW of -$199.77 per acre (Table 9). This financially optimal rotation could produce an estimated 2,856.40 cubic feet of pulpwood and 16.29 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 54.20 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 26 and 36 (with 35 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$321.36 (Table 13), with a NPW of -$319.30 per acre (Table 9). This financially optimal rotation could produce an estimated 3,457.44 cubic feet of pulpwood and 14.56 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 52.97 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 28 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$356.92 (Table 13), with a NPW of -$356.23 per acre (Table 9). This financially optimal rotation could produce an estimated 3,154.06 cubic feet of pulpwood and 13.93 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 52.76 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 26 and 31 (with 35 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$368.60 (Table 13), with a NPW of -$368.38 per acre (Table 9). This financially optimal rotation could

produce an estimated 3,068.55 cubic feet of pulpwood and 13.29 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 51.23 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 25 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $3,455.21 (Table 13), with a NPW of $2,689.05 per acre (Table 9). This financially optimal rotation could produce an estimated 2,567.74 cubic feet of pulpwood and 26.32 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 69.29 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 27 (with 35 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 5). This optimal management regime will generate the maximum SEV of $380.76 (Table 13), with a NPW of $359.36 per acre (Table 9). This financially optimal rotation could produce an estimated 2,774.13 cubic feet of pulpwood and 24.29 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 67.97 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 25 and 30 (with 30 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$154.00 (Table 13), with a NPW of -$150.66 per acre (Table 9). This financially optimal rotation could produce an estimated 3,075.27 cubic feet of pulpwood and 18.99 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 61.98 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 24 and 29 (with 35 percent of basal area removed) and a final harvest at stand age 49 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$300.27 (Table 13), with a NPW of -$297.71 per acre (Table 9). This financially optimal rotation could produce an estimated 3,086.59 cubic feet of pulpwood and 15.19 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 55.54 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 24 and 29 (with 35 percent of basal area removed) and a final harvest at stand age 49 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$347.14 (Table 13), with a NPW of -$346.18 per acre (Table 9). This financially optimal rotation could

produce an estimated 3,086.59 cubic feet of pulpwood and 15.19 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 55.54 net tons of carbon per acre during one rotation (Table 1).

Water oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 24 and 29 (with 35 percent of basal area removed) and a final harvest at stand age 49 are conducted (Table 5). This optimal management regime will generate the maximum SEV of -$363.85 (Table 13), with a NPW of -$363.52 per acre (Table 9). This financially optimal rotation could produce an estimated 3,086.59 cubic feet of pulpwood and 15.19 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 55.54 net tons of carbon per acre during one rotation (Table 1).

<u>Southern- Water oak - Timber + Carbon Rotations (C = $10/ton)</u>

Water oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 29 and 35 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $2,604.08 (Table 14), with a NPW of $2,026.65 per acre (Table 10). This means that $2,604.08 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on

every dollar invested plus $2,026.65 per acre for managing one rotation, or $2,604.08 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 2,669.74 cubic feet of pulpwood and 17.45 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 52.97 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Water oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 29 and 35 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $333.88 (Table 14), with a NPW of $316.86 per acre (Table 10). This financially optimal rotation could produce an estimated 2,669.74 cubic feet of pulpwood and 17.45 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 52.97 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 34 and 41 (with 30 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$129.39 (Table 14), with a NPW of -$127.71 per acre (Table 10). This financially optimal rotation could produce an estimated 3,291.71 cubic feet of pulpwood and 16.01 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 55.81 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 32 and 37 (with 35 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$263.65 (Table 14), with a NPW of -$262.70 per acre (Table 10). This financially optimal rotation could produce an estimated 3,081.81 cubic feet of pulpwood and 15.15 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 51.42 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 32 and 37 (with 35 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$312.13 (Table 14), with a NPW of -$311.83 per acre (Table 10). This financially optimal rotation could produce an estimated 2,901.81 cubic feet of pulpwood and 15.15 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 51.42 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 32 and 38 (with 35 percent of

basal area removed) and a final harvest at stand age 57 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$333.95 (Table 14), with a NPW of -$333.85 per acre (Table 10). This financially optimal rotation could produce an estimated 3,181.19 cubic feet of pulpwood and 13.41 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 50.69 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 27 and 33 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $3,267.30 (Table 14), with a NPW of $2,542.81 per acre (Table 10). This financially optimal rotation could produce an estimated 2,729.26 cubic feet of pulpwood and 21.42 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 61.27 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 28 and 34 (with 25 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $500.20 (Table 14), with a NPW of $473.42 per acre (Table 10). This financially optimal rotation could produce an estimated 2,858.94 cubic feet of pulpwood and 20.64 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 61.11 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 31 and 39 (with 30 percent of basal area removed) and a final harvest at stand age 56 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$58.87 (Table 14), with a NPW of -$57.92 per acre (Table 10). This financially optimal rotation could produce an estimated 3,429.39 cubic feet of pulpwood and 17.86 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 61.58 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 28 and 36 (with 35 percent of basal area removed) and a final harvest at stand age 53 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$226.27 (Table 14), with a NPW of -$224.95 per acre (Table 10). This financially optimal rotation could produce an estimated 3,166.76 cubic feet of pulpwood and 15.09 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 54.78 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 28 and 36 (with 35 percent of

basal area removed) and a final harvest at stand age 52 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -\$289.43 (Table 14), with a NPW of -\$288.87 per acre (Table 10). This financially optimal rotation could produce an estimated 3,310.72 cubic feet of pulpwood and 13.77 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 53.74 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 28 and 34 (with 35 percent of basal area removed) and a final harvest at stand age 51 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -\$318.58 (Table 14), with a NPW of -\$318.35 per acre (Table 10). This financially optimal rotation could produce an estimated 3,384.33 cubic feet of pulpwood and 12.41 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 51.95 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 25 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 6). This optimal management regime will generate the maximum SEV of \$4,039.22 (Table 14), with a NPW of \$3,134.56 per acre (Table 10). This financially optimal rotation could produce an estimated 2,567.74 cubic feet of pulpwood and 26.32 MBF of sawlogs per acre from

the thinning and final harvest (Table 18), and sequester 69.29 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 27 (with 35 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $677.26 (Table 14), with a NPW of $639.19 per acre (Table 10). This financially optimal rotation could produce an estimated 2,774.13 cubic feet of pulpwood and 24.94 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 67.97 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 29 and 36 (with 30 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 6). This optimal management regime will generate the maximum SEV of $20.17 (Table 14), with a NPW of $19.73 per acre (Table 10). This financially optimal rotation could produce an estimated 3,659.68 cubic feet of pulpwood and 18.26 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 65.66 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 27 and 35 (with 35 percent of

basal area removed) and a final harvest at stand age 50 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$184.02 (Table 14), with a NPW of -$182.60 per acre (Table 10). This financially optimal rotation could produce an estimated 3,558.64 cubic feet of pulpwood and 15.90 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 60.81 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 27 and 35 (with 35 percent of basal area removed) and a final harvest at stand age 50 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$263.51 (Table 14), with a NPW of -$262.86 per acre (Table 10). This financially optimal rotation could produce an estimated 3,558.64 cubic feet of pulpwood and 15.90 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 60.81 net tons of carbon per acre during one rotation (Table 2).

Water oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 25 and 31 (with 35 percent of basal area removed) and a final harvest at stand age 49 are conducted (Table 6). This optimal management regime will generate the maximum SEV of -$300.98 (Table 14), with a NPW of -$300.71 per acre (Table 10). This financially optimal rotation could produce an estimated 3,262.36 cubic feet of pulpwood and 15.08 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 56.87 net tons of carbon per acre during one rotation (Table 2).

Southern- Water oak - Timber + Carbon Rotations (C = $37/ton)

Water oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 33 and 41 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $3,692.99 (Table 15), with a NPW of $2,874.11 per acre (Table 11). This means that $3,692.99 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,874.11 per acre for managing one rotation, or $3,692.99 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 3,227.43 cubic feet of pulpwood and 16.30 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 56.23 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Water oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 35 and 45 (with 30 percent of

basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $884.71 (Table 15), with a NPW of $839.60 per acre (Table 11). This financially optimal rotation could produce an estimated 3,495.31 cubic feet of pulpwood and 16.22 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 57.74 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 35 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $199.54 (Table 15), with a NPW of $197.12 per acre (Table 11). This financially optimal rotation could produce an estimated 3,495.31 cubic feet of pulpwood and 16.22 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 57.74 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 38 and 47 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$50.15 (Table 15), with a NPW of -$50.00 per acre (Table 11). This financially optimal rotation could produce an estimated 3,514.06 cubic feet of pulpwood and 16.00 MBF of sawlogs per acre from

the thinning and final harvest (Table 19), and sequester 57.38 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 38 and 47 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$165.54 (Table 15), with a NPW of -$165.41 per acre (Table 11). This financially optimal rotation could produce an estimated 3,514.06 cubic feet of pulpwood and 16.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 57.38 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 38 and 47 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$228.57 (Table 15), with a NPW of -$228.52 per acre (Table 11). This financially optimal rotation could produce an estimated 3,514.06 cubic feet of pulpwood and 16.00 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 57.38 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 30 and 38 (with 25 percent of

basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $4,619.20 (Table 15), with a NPW of $3,594.94 per acre (Table 11). This financially optimal rotation could produce an estimated 3,139.75 cubic feet of pulpwood and 20.92 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 63.82 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 31 and 39 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $1,183.81 (Table 15), with a NPW of $1,123.45 per acre (Table 11). This financially optimal rotation could produce an estimated 3,198.58 cubic feet of pulpwood and 20.81 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 64.26 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 33 and 40 (with 25 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $349.50 (Table 15), with a NPW of $344.59 per acre (Table 11). This financially optimal rotation could produce an estimated 3,333.71 cubic feet of pulpwood and 19.21 MBF of sawlogs per

acre from the thinning and final harvest (Table 19), and sequester 62.81 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 34 and 43 (with 30 percent of basal area removed) and a final harvest at stand age 55 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $44.10 (Table 15), with a NPW of $43.89 per acre (Table 11). This financially optimal rotation could produce an estimated 3,726.58 cubic feet of pulpwood and 16.30 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 61.38 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 34 and 43 (with 30 percent of basal area removed) and a final harvest at stand age 55 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$99.94 (Table 15), with a NPW of -$99.80 per acre (Table 11). This financially optimal rotation could produce an estimated 3,726.58 cubic feet of pulpwood and 16.30 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 61.38 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 37 and 45 (with 30 percent of

basal area removed) and a final harvest at stand age 55 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$179.75 (Table 15), with a NPW of -$179.67 per acre (Table 11). This financially optimal rotation could produce an estimated 3,871.29 cubic feet of pulpwood and 15.57 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 61.14 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 25 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $5,616.04 (Table 15), with a NPW of $4,370.74 per acre (Table 11). This financially optimal rotation could produce an estimated 2,567.74 cubic feet of pulpwood and 26.32 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 69.29 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 28 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $1,493.36 (Table 15), with a NPW of $1,417.22 per acre (Table 11). This financially optimal rotation could produce an estimated 2,963.08 cubic feet of pulpwood and 25.40 MBF of sawlogs per acre from

the thinning and final harvest (Table 19), and sequester 71.15 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 30 and 37 (with 25 percent of basal area removed) and a final harvest at stand age 55 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $512.68 (Table 15), with a NPW of $503.75 per acre (Table 11). This financially optimal rotation could produce an estimated 3,498.78 cubic feet of pulpwood and 20.71 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 68.26 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 29 and 38 (with 30 percent of basal area removed) and a final harvest at stand age 52 are conducted (Table 7). This optimal management regime will generate the maximum SEV of $149.36 (Table 15), with a NPW of $148.40 per acre (Table 11). This financially optimal rotation could produce an estimated 3,793.55 cubic feet of pulpwood and 18.12 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 66.50 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 39 and 44 (with 25 percent of

basal area removed) and a final harvest at stand age 54 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$25.69 (Table 15), with a NPW of -$25.65 per acre (Table 11). This financially optimal rotation could produce an estimated 4,031.41 cubic feet of pulpwood and 18.38 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 68.42 net tons of carbon per acre during one rotation (Table 3).

Water oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 39 and 44 (with 25 percent of basal area removed) and a final harvest at stand age 54 are conducted (Table 7). This optimal management regime will generate the maximum SEV of -$123.48 (Table 15), with a NPW of -$123.42 per acre (Table 11). This financially optimal rotation could produce an estimated 4,031.41 cubic feet of pulpwood and 18.38 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 68.42 net tons of carbon per acre during one rotation (Table 3).

<u>Southern- Water oak - Timber + Carbon Rotations (C = $50/ton)</u>

Water oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 35 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $4,246.19 (Table 16), with a NPW of $3,304.64 per acre (Table 12). This means that $4,246.19 is the

maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $3,304.64 per acre for managing one rotation, or $4,246.19 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 3,495.31 cubic feet of pulpwood and 16.22 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 57.74 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Water oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 35 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $1,155.18 (Table 16), with a NPW of $1,096.29 per acre (Table 12). This financially optimal rotation could produce an estimated 3,495.31 cubic feet of pulpwood and 16.22 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 57.74 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 38 and 47 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This

optimal management regime will generate the maximum SEV of $360.05 (Table 16), with a NPW of $355.68 per acre (Table 12). This financially optimal rotation could produce an estimated 3,514.06 cubic feet of pulpwood and 16.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 57.38 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 38 and 47 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $54.04 (Table 16), with a NPW of $53.88 per acre (Table 12). This financially optimal rotation could produce an estimated 3,514.06 cubic feet of pulpwood and 16.00 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 57.38 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 44 and 50 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$94.17 (Table 16), with a NPW of -$94.10 per acre (Table 12). This financially optimal rotation could produce an estimated 3,807.14 cubic feet of pulpwood and 14.15 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 56.52 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 45 and 53 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$177.24 (Table 16), with a NPW of -$177.21 per acre (Table 12). This financially optimal rotation could produce an estimated 3,975.43 cubic feet of pulpwood and 13.33 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 56.38 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 31 and 39 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $5,282.58 (Table 16), with a NPW of $4,111.22 per acre (Table 12). This financially optimal rotation could produce an estimated 3,198.58 cubic feet of pulpwood and 20.81 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 64.26 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 31 and 39 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $1,514.61 (Table 16),

with a NPW of $1,437.39 per acre (Table 12). This financially optimal rotation could produce an estimated 3,198.58 cubic feet of pulpwood and 20.81 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 64.26 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 33 and 40 (with 25 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $549.64 (Table 16), with a NPW of $541.93 per acre (Table 12). This financially optimal rotation could produce an estimated 3,333.71 cubic feet of pulpwood and 19.21 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 62.81 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 37 and 42 (with 25 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $176.41 (Table 16), with a NPW of $175.71 per acre (Table 12). This financially optimal rotation could produce an estimated 3,569.40 cubic feet of pulpwood and 17.87 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 62.44 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 53 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$7.15 (Table 16), with a NPW of -$7.15 per acre (Table 12). This financially optimal rotation could produce an estimated 3,831.59 cubic feet of pulpwood and 18.12 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 64.31 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 53 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$111.84 (Table 16), with a NPW of -$111.82 per acre (Table 12). This financially optimal rotation could produce an estimated 3,831.59 cubic feet of pulpwood and 18.12 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 64.31 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning at stand age 25 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $6,375.25 (Table 16), with a NPW of $4,961.60 per acre (Table 12). This financially optimal rotation could produce

an estimated 2,567.74 cubic feet of pulpwood and 26.32 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 69.29 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning at stand age 28 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $1,893.46 (Table 16), with a NPW of $1,796.42 per acre (Table 12). This financially optimal rotation could produce an estimated 2,963.08 cubic feet of pulpwood and 25.40 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 71.15 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 30 and 37 (with 25 percent of basal area removed) and a final harvest at stand age 55 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $754.23 (Table 16), with a NPW of $741.09 per acre (Table 12). This financially optimal rotation could produce an estimated 3,498.78 cubic feet of pulpwood and 20.71 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 68.26 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 39 and 44 (with 25 percent of basal area removed) and a final harvest at stand age 54 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $313.21 (Table 16), with a NPW of $311.55 per acre (Table 12). This financially optimal rotation could produce an estimated 4,031.41 cubic feet of pulpwood and 18.38 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 68.42 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 39 and 44 (with 25 percent of basal area removed) and a final harvest at stand age 54 are conducted (Table 8). This optimal management regime will generate the maximum SEV of $91.92 (Table 16), with a NPW of $91.78 per acre (Table 12). This financially optimal rotation could produce an estimated 4,031.41 cubic feet of pulpwood and 18.38 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 68.42 net tons of carbon per acre during one rotation (Table 4).

Water oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 52 (with 30 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 8). This optimal management regime will generate the maximum SEV of -$36.37 (Table 16), with a NPW of -$36.36 per acre (Table 12). This financially optimal rotation could produce an

estimated 3,959.48 cubic feet of pulpwood and 20.55 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 71.05 net tons of carbon per acre during one rotation (Table 4).

Western hemlock (*Tsuga heterophylla*)

Biological Information

Western hemlock is an important commercial species of the northern Rocky Mountains and Pacific coast. It thrives in a mild, humid climate where frequent fog and precipitation occur during the growing season. Along the Pacific coast, it extends north from central California to the Kenai Peninsula in Alaska, Inland it grows along the western and upper eastern Cascade Range in Oregon and Washington to the west side of the Continental Divide of the northern Rocky Mountains in Montana and Idaho (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_1/tsuga/heterophylla.htm. May 12, 2006) (Fig. 1).

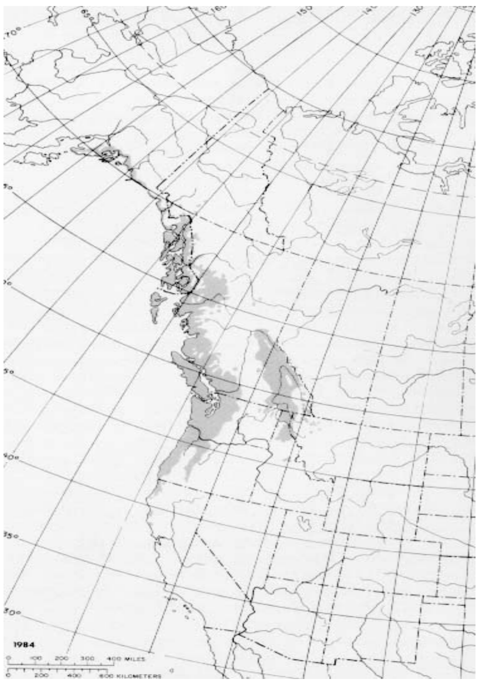

Fig. 1. The native range of yellow-poplar (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_1/tsuga/heterophylla.htm. May 12, 2006)

Western hemlock forests are among the most productive forests in the world. Western hemlock at maturity can reach up to 259 feet in height with a d.b.h. of 108 inches. More commonly height range is from 165 to 200 feet with a d.b.h. of 39.6 inches. Site indices ranging from 85 to 200 feet on base age 100 curves are not uncommon. The maximum attainable age is between 400 and 500 years. Yields of western hemlock on the best sites can exceed 26,400 ft^3/acre at 100 years of age (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_1/tsuga/heterophylla.htm. May 12, 2006).

Western hemlock is rated to be very tolerant of shade. Advance regeneration can survive in the understory for 50 to 60 years. Under dense conditions early natural pruning occurs, and stem development is good. It is a climax species either alone or in combination with its shade-tolerant associates (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_1/tsuga/heterophylla.htm. May 12, 2006).

Western hemlock has been long recognized as a general all purpose raw material. It has been used for pilings, poles, and railway ties. It is a preferred species for construction lumber. Western hemlock also exhibits excellent pulp characteristics, and is an important fiber source for the pulping industry (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_1/tsuga/heterophylla.htm. May 12, 2006).

Economic Background

Nelson, Brodie, and Sessions (1991) integrated a short-term area based logging plan with a long-term strata-based harvesting schedule. The long term plan was developed using a linear programming technique, while the short-term plan used mixed-integer programming. Integrating the two plans indicated that total and long-term net revenue would always be overestimated using the strata-based approach, while underestimating long-term volumes. This is understandable because the addition of the short-term plan limited the timing choices available to the linear program. The addition of more constraints decreased the feasible region and lowered the optimal objective function value.

Kellogg and Olsen (1988) conducted an economic evaluation of thinning alternatives in a western hemlock-Sitka spruce forest. All stands in the study had been precommercially thinned, and were 32 years of age at the beginning of the project. Stand table information such as height diameter at breast height and number of trees were input into the harvest model YARDALL to develop yarding/loading costs, and gross revenue. Pond values (log gate prices) for five log classes were assigned based on values obtained from the Oregon Department of Revenue, Timber Tax Division, for northwest Oregon. Final costs and revenues were discounted to age 32 using a real interest rate of 4%. The results indicated that for a 70 year rotation the optimal net present worth (NPW) was obtained from the control plots ($2,868) versus the second best ($2,086). This indicates that NPW is highest in a rotation where no commercial thinnings are conducted, because of high costs and low prices for small logs.

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Species ___Western hemlock______ Region Pacific Northwest Coast

Site indices 90, 100 and 110 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 4.5-in. inside bark top diameter for trees with a minimum of 7 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 9-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 15 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.187943262 and 0.709219858, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Grier and Logan (1977) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Y = \exp(-2.172 + 2.257 \ln X)$$

where:

Y = component dry weight (kg)

X = stem diameter at breast height (cm)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.6% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $193/mbf (Scribner) (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices) and pulpwood price was assumed to be $0/cord (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of western hemlock plantations on the Pacific Northwest Coast.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$80.28	Only once	Year 0	
Seedlings[b] (600 seedlings/ac)	$132	Only Once	Year 0	
Burning[a]	$21.24	Every 5 years	Year 10	Final Harvest
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al (2005).

[b]The seedling cost was estimated based on the seedling prices from Drakes Crossing Nursery (http://www.drakescrossingnursery.com/catalog.htm.February 12, 2006).

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Table 1. Total tons of carbon sequestered per acre for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	28.07	28.07	21.78	20.60	20.60	20.60
100	38.54	27.84	23.38	20.94	19.66	19.66
110	39.79	27.52	25.20	21.29	21.29	18.59

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	28.07	28.07	21.78	22.41	20.60	20.60
100	38.54	27.84	24.51	20.94	19.60	19.66
110	39.89	27.52	25.20	25.20	21.29	21.29

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	28.07	28.07	23.98	21.78	20.60	20.60
100	38.65	27.84	24.51	23.38	20.94	19.66
110	37.32	39.05	30.58	30.58	30.58	30.58

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	28.07	28.07	23.98	21.78	20.60	20.60
100	38.65	27.84	26.79	23.38	20.94	20.94
110	39.89	39.05	34.71	30.58	30.58	30.58

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	**30**[2]	**30**	**24**	**23**	<**23**>[3]	<**23**>
100	34-**39** (30%)[4]	**27**	**23**	**21**	<**20**>	<**20**>
110	32-**37** (30%)	**24**	**22**	**19**	**19**	<**17**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	**30**[2]	**30**	**24**	20-**25** (20%)[3]	<**23**>[4]	<**23**>
100	34-**39** (30%)	**27**	**24**	**21**	**20**	<**20**>
110	32-**37** (20%)	**24**	**22**	**22**	**19**	<**19**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	**30**[2]	**30**	**26**	**24**	**23**	<**23**>[3]
100	34-**39** (25%)[4]	**27**	**24**	**23**	**21**	**20**
110	**34**	31-**36** (20%)	22-**27** (20%)	22-**27** (20%)	22-**27** (20%)	22-**27** (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	**30**[2]	**30**	**26**	**24**	**23**	**23**
100	34-**39** (25%)[3]	**27**	**26**	**23**	**21**	**21**
110	32-**37** (20%)	31-**36** (20%)	26-**31** (20%)	22-**27** (20%)	22-**27** (20%)	22-**27** (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,824.76	$1,163.42	$399.49	$71.02	-$112.35	-$219.12
100	$3,921.77	$1,418.51	$567.04	$182.57	-$27.14	-$152.71
110	$4,497.39	$1,664.45	$782.34	$307.93	$68.46	-$81.78

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$3,038.58	$1,324.12	$501.58	$133.33	-$50.61	-$169.34
100	$4,214.68	$1,589.79	$698.05	$271.40	$43.07	-$94.41
110	$4,891.98	$1,846.81	$920.84	$432.60	$154.33	-$11.93

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$3,615.89	$1,758.00	$808.98	$362.46	$116.09	-$34.95
100	$5,005.53	$2,052.25	$1,029.06	$527.57	$239.04	$63.01
110	$5,332.00	$2,897.89	$1,449.48	$848.21	$485.87	$258.74

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$3,893.86	$1,966.90	$950.87	$466.56	$196.36	$29.75
100	$5,387.64	$2,274.91	$1,223.17	$651.19	$333.54	$140.63
110	$6,506.95	$3,332.79	$1,820.01	$1,087.73	$684.79	$424.54

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$5,281.05	$1,492.26	$477.84	$79.05	-$119.42	-$227.05
100	$6,249.14	$1,904.28	$688.39	$208.14	-$29.64	-$161.28
110	$7,388.33	$2,361.94	$965.25	$361.69	$75.63	-$88.97

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$5,680.80	$1,698.37	$599.96	$145.55	-$53.80	-$175.47
100	$6,715.87	$2,134.21	$834.97	$309.41	$47.04	-$99.71
110	$8,036.57	$2,620.71	$1,136.14	$486.99	$170.50	-$12.70

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$6,760.13	$2,254.88	$942.75	$399.32	$123.40	-$36.22
100	$7,976.06	$2,755.04	$1,230.90	$587.18	$258.40	$66.54
110	$9,214.89	$3,468.18	$1,669.91	$911.41	$504.52	$264.01

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for western hemlock plantations by site index and real alternative rates of return in the Pacific Northwest region. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$7,279.80	$2,522.83	$1,108.10	$514.00	$208.72	$30.83
100	$8,584.93	$3,053.96	$1,425.43	$724.77	$360.55	$147.45
110	$10,689.65	$3,988.68	$2,019.62	$1,168.77	$711.08	$433.19

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for western hemlock plantations by soil productivity and real alternative rates of return in the Pacific Northwest region). (carbon value = $0/ton)

			1st thinning	2nd thinning	Final harvest	Total volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
90	2.50%	**30**[3]	-[4]	-	37.44	37.44
	5.00%	**30**	-	-	37.44	37.44
	7.50%	**24**	-	-	25.09	25.09
	10.00%	**23**	-	-	23.09	23.09
	12.50%	**23**	-	-	23.09	23.09
	15.00%	**23**	-	-	23.09	23.09
100	2.50%	34-**39** (30%)[5]	16.28	-	43.14	59.42
	5.00%	**27**	-	-	37.56	37.56
	7.50%	**23**	-	-	28.25	28.25
	10.00%	**21**	-	-	23.72	23.72
	12.50%	**20**	-	-	21.29	21.29
	15.00%	**20**	-	-	21.29	21.29
110	2.50%	32-**37** (30%)	17.14	-	47.12	64.26
	5.00%	**24**	-	-	36.87	36.87
	7.50%	**22**	-	-	32.15	32.15
	10.00%	**19**	-	-	23.76	23.76
	12.50%	**19**	-	-	23.76	23.76
	15.00%	**17**	-	-	18.2	18.2

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Indicates no operation conducted.
[5]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 18. Volume removed from the financially optimal schedules for western hemlock plantations by soil productivity and real alternative rates of return in the Pacific Northwest region. (carbon value = $10/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final harvest MBF	Total volume MBF
90	2.50%	**30**[3]	-[4]	-	37.44	37.44
	5.00%	**30**	-	-	37.44	37.44
	7.50%	**24**	-	-	25.09	25.09
	10.00%	20-**25** (20%)[5]	0	-	26.88	26.88
	12.50%	**23**	-	-	23.09	23.09
	15.00%	**23**	-	-	23.09	23.09
100	2.50%	34-**39** (30%)	16.28	-	43.14	59.42
	5.00%	**27**	-	-	37.56	37.56
	7.50%	**24**	-	-	30.57	30.57
	10.00%	**21**	-	-	23.72	23.72
	12.50%	**20**	-	-	21.29	21.29
	15.00%	**20**	-	-	21.29	21.29
110	2.50%	32-**37** (20%)	11.99	-	52.78	64.77
	5.00%	**24**	-	-	36.87	36.87
	7.50%	**22**	-	-	32.15	32.15
	10.00%	**22**	-	-	32.15	32.15
	12.50%	**19**	-	-	23.76	23.76
	15.00%	**19**	-	-	23.76	23.76

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for western hemlock plantations by soil productivity and real alternative rates of return in the Pacific Northwest region. (carbon value = $37/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final harvest MBF	Total volume MBF
90	2.50%	**30**[3]	-[4]	-	37.44	37.44
	5.00%	**30**	-	-	37.44	37.44
	7.50%	**26**	-	-	29.22	29.22
	10.00%	**24**	-	-	25.09	25.09
	12.50%	**23**	-	-	23.09	23.09
	15.00%	**23**	-	-	23.09	23.09
100	2.50%	34-**39** (25%)[5]	13.71	-	45.96	59.67
	5.00%	**27**	-	-	37.56	37.56
	7.50%	**24**	-	-	30.57	30.57
	10.00%	**23**	-	-	28.25	28.25
	12.50%	**21**	-	-	23.72	23.72
	15.00%	**20**	-	-	21.29	21.29
110	2.50%	**34**	-	-	58.44	58.44
	5.00%	31-**36** (20%)	11.25	-	50.91	62.16
	7.50%	22-**27** (20%)	2.85	-	35.99	38.84
	10.00%	22-**27** (20%)	2.85	-	35.99	38.84
	12.50%	22-**27** (20%)	2.85	-	35.99	38.84
	15.00%	22-**27** (20%)	2.85	-	35.99	38.84

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for western hemlock plantations by soil productivity and real alternative rates of return in the Pacific Northwest region. (carbon value = $50/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final harvest MBF	Total volume MBF
90	2.50%	**30**[3]	-[4]	-	37.44	37.44
	5.00%	**30**	-	-	37.44	37.44
	7.50%	**26**	-	-	29.22	29.22
	10.00%	**24**	-	-	25.09	25.09
	12.50%	**23**	-	-	23.09	23.09
	15.00%	**23**	-	-	23.09	23.09
100	2.50%	34-**39** (25%)[5]	13.71	-	45.96	59.67
	5.00%	**27**	-	-	37.56	37.56
	7.50%	**26**	-	-	35.2	35.2
	10.00%	**23**	-	-	28.25	28.25
	12.50%	**21**	-	-	23.72	23.72
	15.00%	**21**	-	-	23.72	23.72
110	2.50%	32-**37** (20%)	11.99	-	52.78	64.77
	5.00%	31-**36** (20%)	11.25	-	50.91	62.16
	7.50%	26-**31** (20%)	6.93	-	41.37	48.3
	10.00%	22-**27** (20%)	2.85	-	35.99	38.84
	12.50%	22-**27** (20%)	2.85	-	35.99	38.84
	15.00%	22-**27** (20%)	2.85	-	35.99	38.84

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for western hemlock plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	90	**30**[2]	**30**	0%	**30**	0%	**30**	0%
	100	34-**39** (30%)[3]	34-**39** (30%)	0%	34-**39** (25%)	0%	34-**39** (25%)	0%
	110	32-**37** (30%)	32-**37** (20%)	0%	**34**	-8%	32-**37** (20%)	0%
5.00%	90	**30**	**30**	0%	**30**	0%	**30**	0%
	100	**27**	**27**	0%	**27**	0%	**27**	0%
	110	**24**	**24**	0%	31-**36** (20%)	50%	31-**36** (20%)	50%
7.50%	90	**24**	**24**	0%	**26**	8%	**26**	8%
	100	**23**	**24**	4%	**24**	4%	**26**	13%
	110	**22**	**22**	0%	22-**27** (20%)	23%	26-**31** (20%)	41%
10.00%	90	**23**	20-**25** (20%)	9%	**24**	4%	**24**	4%
	100	**21**	**21**	0%	**23**	10%	**23**	10%
	110	**19**	**22**	16%	22-**27** (20%)	42%	22-**27** (20%)	42%
12.50%	90	**<23>**[4]	**<23>**	0%	**23**	0%	**23**	0%
	100	**<20>**	**20**	0%	**21**	5%	**21**	5%
	110	**19**	**19**	0%	22-**27** (20%)	42%	22-**27** (20%)	42%
15.00%	90	**<23>**	**<23>**	0%	**<23>**	0%	**23**	0%
	100	**<20>**	**<20>**	0%	**20**	0%	**21**	5%
	110	**<17>**	**<19>**	12%	22-**27** (20%)	59%	22-**27** (20%)	59%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning
[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for western hemlock plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	90	5,281.05	5,680.80	8%	6,760.13	28%	7,279.80	38%
	100	6,249.14	6,715.87	7%	7,976.06	28%	8,584.93	37%
	110	7,388.33	8,036.57	9%	9,214.89	25%	10,689.65	45%
5.00%	90	1,492.26	1,698.37	14%	2,254.88	51%	2,522.83	69%
	100	1,904.28	2,134.21	12%	2,755.04	45%	3,053.96	60%
	110	2,361.94	2,620.71	11%	3,468.18	47%	3,988.68	69%
7.50%	90	477.84	599.96	26%	942.75	97%	1,108.10	132%
	100	688.39	834.97	21%	1,230.90	79%	1,425.43	107%
	110	965.25	1,136.14	18%	1,669.91	73%	2,019.62	109%
10.00%	90	79.05	145.55	84%	399.32	405 %	514.00	550%
	100	208.14	309.41	49%	587.18	182 %	724.77	248%
	110	361.69	486.99	35%	911.41	152 %	1,168.77	223%
12.50%	90	-119.42	-53.80		123.40		208.72	
	100	-29.64	47.04		258.40		360.55	
	110	75.63	170.50		504.52		711.08	
15.00%	90	-227.05	-175.47		-36.22		30.83	
	100	-161.28	-99.71		66.54		147.45	
	110	-88.97	-12.70		264.01		433.19	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>Pacific Northwest- Western hemlock - Timber Only Rotations (C = $0/ton)</u>

Western hemlock, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 30 (Table 5). This optimal management regime will generate the maximum SEV of $5,281.05 (Table 13), with a NPW of $2,824.76 per acre (Table 9). This means that $5,281.05 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 90 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,824.76 per acre for managing one rotation, or $5,281.05 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 37.44 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 28.07 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Western hemlock, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 30 (Table 5). This optimal management regime will generate the maximum SEV of $1,492.26 (Table 13), with a NPW of $1,163.42 per acre (Table 9). This financially optimal rotation would produce an estimated 37.44 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 28.07 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 24 (Table 5). This optimal management regime will generate the maximum SEV of $477.84 (Table 13), with a NPW of $399.49 per acre (Table 9). This financially optimal rotation would produce an estimated 25.09 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 21.78 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 5). This optimal management regime will generate the maximum SEV of $79.05 (Table 13), with a NPW of $71.02 per acre (Table 9). This financially optimal rotation would produce an estimated 23.09 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 20.60 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 5). This optimal management regime will generate the maximum SEV of -$119.42 (Table 13), with a NPW of -$112.35 per acre (Table 9). This financially optimal rotation would produce an estimated 23.09 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 20.60 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 5). This optimal management regime will generate the maximum SEV of -$227.05 (Table 13), with a NPW of -$219.12 per acre (Table 9). This financially optimal rotation would produce an estimated 23.09 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 20.60 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 39 (Table 5). This optimal management regime will generate the maximum SEV of $6,249.14 (Table 13), with a NPW of $3,921.77 per acre (Table 9). This financially optimal rotation would produce an estimated 59.42 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 38.54 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 5). This optimal management regime will generate the maximum SEV of $1,904.28 (Table 13), with a NPW of $1,418.51 per acre (Table 9). This financially optimal rotation would

produce an estimated 37.56 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 27.84 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 5). This optimal management regime will generate the maximum SEV of $688.39 (Table 13), with a NPW of $567.04 per acre (Table 9). This financially optimal rotation would produce an estimated 28.25 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 23.38 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 5). This optimal management regime will generate the maximum SEV of $208.14 (Table 13), with a NPW of -$182.57 per acre (Table 9). This financially optimal rotation would produce an estimated 23.72 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 20.94 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 5). This optimal management regime will generate the maximum SEV of -$29.64 (Table 13), with

a NPW of -$27.14 per acre (Table 9). This financially optimal rotation would produce an estimated 21.29 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 19.66 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 5). This optimal management regime will generate the maximum SEV of -$161.28 (Table 13), with a NPW of -$152.71 per acre (Table 9). This financially optimal rotation would produce an estimated 21.29 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 19.66 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 37 (Table 5). This optimal management regime will generate the maximum SEV of $7,388.33 (Table 13), with a NPW of $4,497.39 per acre (Table 9). This financially optimal rotation would produce an estimated 64.26 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 39.79 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 24 (Table 5). This optimal management regime will generate the maximum SEV of $2,361.94 (Table 13), with a NPW of $1,664.45 per acre (Table 9). This financially optimal rotation would produce an estimated 36.87 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 27.52 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 5). This optimal management regime will generate the maximum SEV of $965.25 (Table 13), with a NPW of $782.34 per acre (Table 9). This financially optimal rotation would produce an estimated 32.15 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 25.20 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 5). This optimal management regime will generate the maximum SEV of $361.69 (Table 13), with a NPW of $307.93 per acre (Table 9). This financially optimal rotation would produce an estimated 23.76 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 21.29 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 5). This optimal management regime will generate the maximum SEV of $75.63 (Table 13), with a NPW of $68.46 per acre (Table 9). This financially optimal rotation would produce an estimated 23.76 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 21.29 net tons of carbon per acre during one rotation (Table 1).

Western hemlock, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 17 (Table 5). This optimal management regime will generate the maximum SEV of -$88.97 (Table 13), with a NPW of -$81.78 per acre (Table 9). This financially optimal rotation would produce an estimated 18.20 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 18.59 net tons of carbon per acre during one rotation (Table 1).

Pacific Northwest- Western hemlock - Timber + Carbon Rotations (C = $10/ton)

Western hemlock, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 30 (Table 6). This optimal management regime will generate the maximum SEV of $5,680.80 (Table 14),

with a NPW of $3,038.58 per acre (Table 10). This means that $5,680.80 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 90 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $3,038.58 per acre for managing one rotation, or $5,680.80 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 37.44 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 28.07 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Western hemlock, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 30 (Table 6). This optimal management regime will generate the maximum SEV of $1,698.37 (Table 14), with a NPW of $1,324.12 per acre (Table 10). This financially optimal rotation would produce an estimated 37.44 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 28.07 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 24 (Table 6). This

optimal management regime will generate the maximum SEV of $599.96 (Table 14), with a NPW of $501.58 per acre (Table 10). This financially optimal rotation would produce an estimated 25.09 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 21.78 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 20 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 25 (Table 6). This optimal management regime will generate the maximum SEV of $145.55 (Table 14), with a NPW of $133.33 per acre (Table 10). This financially optimal rotation would produce an estimated 26.88 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.41 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 6). This optimal management regime will generate the maximum SEV of -$53.80 (Table 14), with a NPW of -$50.61 per acre (Table 10). This financially optimal rotation would produce an estimated 23.09 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 20.60 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 6). This optimal management regime will generate the maximum SEV of -$175.47 (Table 14), with a NPW of -$169.34 per acre (Table 10). This financially optimal rotation would produce an estimated 23.09 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 20.60 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 39 (Table 6). This optimal management regime will generate the maximum SEV of $6,715.87 (Table 14), with a NPW of $4,214.68 per acre (Table 10). This financially optimal rotation would produce an estimated 59.42 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 38.54 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 6). This optimal management regime will generate the maximum SEV of $2,134.21 (Table 14), with a NPW of $1,589.79 per acre (Table 10). This financially optimal rotation would produce an estimated 37.56 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 27.84 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 24 (Table 6). This optimal management regime will generate the maximum SEV of $834.97 (Table 14), with a NPW of $698.05 per acre (Table 10). This financially optimal rotation would produce an estimated 30.57 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 24.51 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 6). This optimal management regime will generate the maximum SEV of $309.41 (Table 14), with a NPW of $271.40 per acre (Table 10). This financially optimal rotation would produce an estimated 23.72 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 20.94 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 6). This optimal management regime will generate the maximum SEV of $47.04 (Table 14), with a NPW of $43.07 per acre (Table 10). This financially optimal rotation would produce

an estimated 21.29 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 19.60 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 6). This optimal management regime will generate the maximum SEV of -$99.71 (Table 14), with a NPW of -$94.41 per acre (Table 10). This financially optimal rotation would produce an estimated 21.29 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 19.60 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 37 (Table 6). This optimal management regime will generate the maximum SEV of $8,036.57 (Table 14), with a NPW of $4,891.98 per acre (Table 10). This financially optimal rotation would produce an estimated 64.77 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 39.89 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 24 (Table 6). This

optimal management regime will generate the maximum SEV of $2,620.71 (Table 14), with a NPW of $1,846.81 per acre (Table 10). This financially optimal rotation could produce an estimated 36.87 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 27.52 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest in conducted at stand age 22 (Table 6). This optimal management regime will generate the maximum SEV of $1,136.14 (Table 14), with a NPW of $920.84 per acre (Table 10). This financially optimal rotation would produce an estimated 32.15 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 25.20 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 22 (Table 6). This optimal management regime will generate the maximum SEV of $486.99 (Table 14), with a NPW of $432.60 per acre (Table 10). This financially optimal rotation would produce an estimated 32.15 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 25.20 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 6). This optimal management regime will generate the maximum SEV of $170.50 (Table 14), with a NPW of $154.33 per acre (Table 10). This financially optimal rotation would produce an estimated 23.76 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 21.29 net tons of carbon per acre during one rotation (Table 2).

Western hemlock, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 19 (Table 6). This optimal management regime will generate the maximum SEV of -$12.70 (Table 14), with a NPW of -$11.93 per acre (Table 10). This financially optimal rotation would produce an estimated 23.76 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 21.29 net tons of carbon per acre during one rotation (Table 2).

<u>Pacific Northwest- Western hemlock - Timber + Carbon Rotations (C = $37/ton)</u>

Western hemlock, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 30 (Table 7). This optimal management regime will generate the maximum SEV of $6,760.13 (Table 15), with a NPW of $3,615.89 per acre (Table 11). This means that $6,760.13 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 90 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $3,615.89 per acre for managing one rotation, or $6,760.13 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 37.44 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 28.07 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Western hemlock, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 30 (Table 7). This optimal management regime will generate the maximum SEV of $2,254.88 (Table 15), with a NPW of $1,758.00 per acre (Table 11). This financially optimal rotation would produce an estimated 37.44 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 28.07 net tons of carbon per acre during one rotation (Table 3).

Western hemlock, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 26 (Table 7). This optimal management regime will generate the maximum SEV of $942.75 (Table 15), with a NPW of $808.98 per acre (Table 11). This financially optimal rotation would

produce an estimated 29.22 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 23.98 net tons of carbon per acre during one rotation (Table 3).

Western hemlock, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 24 (Table 7). This optimal management regime will generate the maximum SEV of $399.32 (Table 15), with a NPW of $362.46 per acre (Table 11). This financially optimal rotation would produce an estimated 25.09 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 21.78 net tons of carbon per acre during one rotation (Table 3).

Western hemlock, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 7). This optimal management regime will generate the maximum SEV of $123.40 (Table 15), with a NPW of $116.09 per acre (Table 11). This financially optimal rotation would produce an estimated 23.09 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 20.60 tons of carbon per acre during the rotation (Table 3).

Western hemlock, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 7). This optimal management regime will generate the maximum SEV of -$36.22 (Table 15), with

a NPW of -$34.95 per acre (Table 11). This financially optimal rotation would produce an estimated 23.09 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 20.60 tons of carbon per acre during the rotation (Table 3).

Western hemlock, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 39 (Table 7). This optimal management regime will generate the maximum SEV of $7,976.06 (Table 15), with a NPW of $5,005.53 per acre (Table 11). This financially optimal rotation would produce an estimated 59.67 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 38.65 net tons of carbon per acre during one rotation (Table 3).

Western hemlock, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 7). This optimal management regime will generate the maximum SEV of $2,755.04 (Table 15), with a NPW of $2,052.25 per acre (Table 11). This financially optimal rotation would produce an estimated 37.56 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 27.84 net tons of carbon per acre during one rotation (Table 3).

Western hemlock, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 24 (Table 7). This optimal management regime will generate the maximum SEV of $1,230.90 (Table 15), with a NPW of $1,029.06 per acre (Table 11). This financially optimal rotation would produce an estimated 30.57 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 24.51 net tons of carbon per acre during one rotation (Table 3).

Western hemlock, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 7). This optimal management regime will generate the maximum SEV of $587.18 (Table 15), with a NPW of $527.57 per acre (Table 11). This financially optimal rotation would produce an estimated 28.25 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 23.38 net tons of carbon per acre during one rotation (Table 3).

Western hemlock, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 7). This optimal management regime will generate the maximum SEV of $258.40 (Table 15), with a NPW of $239.04 per acre (Table 11). This financially optimal rotation would produce an estimated 23.72 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 20.94 net tons of carbon per acre during one rotation (Table 3).

Western hemlock, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 7). This optimal management regime will generate the maximum SEV of $66.54 (Table 15), with a NPW of $63.01 per acre (Table 11). This financially optimal rotation would produce an estimated 21.29 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 19.66 net tons of carbon per acre during one rotation (Table 3).

Western hemlock, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 34 (Table 7). This optimal management regime will generate the maximum SEV of $9,214.89 (Table 15), with a NPW of $5,332.00 per acre (Table 11). This financially optimal rotation would produce an estimated 58.44 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 37.32 net tons of carbon per acre during one rotation (Table 3).

Western hemlock, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 36 (Table 7). This optimal management regime will generate the maximum SEV of $3,468.18 (Table 15), with a NPW of $2,897.89 per acre (Table 11). This financially optimal rotation would

produce an estimated 62.16 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 39.05 net tons of carbon per acre during one rotation (Table 3).

Western hemlock, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand ages 22 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 7). This optimal management regime will generate the maximum SEV of $1,669.91 (Table 15), with a NPW of $1,449.48 per acre (Table 11). This financially optimal rotation would produce an estimated 38.84 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 30.58 net tons of carbon per acre during one rotation (Table 3).

Western hemlock, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand ages 22 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 7). This optimal management regime will generate the maximum SEV of $911.41 (Table 15), with a NPW of $848.21 per acre (Table 11). This financially optimal rotation would produce an estimated 38.84 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 30.58 net tons of carbon per acre during one rotation (Table 3).

Western hemlock, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand ages 22 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 7). This optimal management regime will generate the maximum SEV of $504.52 (Table 15), with a NPW of $485.87 per acre (Table 11). This financially optimal rotation would produce an estimated 38.84 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 30.58 tons of carbon per acre during one rotation (Table 3).

Western hemlock, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand ages 22 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 7). This optimal management regime will generate the maximum SEV of $264.01 (Table 15), with a NPW of $258.74 per acre (Table 11). This financially optimal rotation would produce an estimated 38.84 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 30.58 net tons of carbon per acre during one rotation (Table 3).

Pacific Northwest- Western hemlock - Timber + Carbon Rotations (C = $50/ton)

Western hemlock, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 30 (Table 8). This optimal management regime will generate the maximum SEV of $7,279.80 (Table 16),

with a NPW of $3,893.86 per acre (Table 12). This means that $7,279.80 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 90 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $3,893.86 per acre for managing one rotation, or $7,279.80 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 37.44 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 28.07 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Western hemlock, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 30 (Table 8). This optimal management regime will generate the maximum SEV of $2,522.83 (Table 16), with a NPW of $1,966.90 per acre (Table 12). This financially optimal rotation would produce an estimated 37.44 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 28.07 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 26 (Table 8). This

optimal management regime will generate the maximum SEV of $1,108.10 (Table 16), with a NPW of $950.87 per acre (Table 12). This financially optimal rotation would produce an estimated 29.22 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 23.98 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 24 (Table 8). This optimal management regime will generate the maximum SEV of $514.00 (Table 16), with a NPW of $466.56 per acre (Table 12). This financially optimal rotation would produce an estimated 25.09 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 21.78 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 8). This optimal management regime will generate the maximum SEV of $208.72 (Table 16), with a NPW of $196.36 per acre (Table 12). This financially optimal rotation would produce an estimated 23.09 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 20.60 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 8). This optimal management regime will generate the maximum SEV of $30.83 (Table 16), with a NPW of $29.75 per acre (Table 12). This financially optimal rotation would produce an estimated 23.09 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 20.60 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 34 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 39 (Table 8). This optimal management regime will generate the maximum SEV of $8,584.93 (Table 16), with a NPW of $5,387.64 per acre (Table 12). This financially optimal rotation would produce an estimated 59.67 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 38.65 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 27 (Table 8). This optimal management regime will generate the maximum SEV of $3,053.96 (Table 16), with a NPW of $2,274.91 per acre (Table 12). This financially optimal rotation would produce an estimated 37.56 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 27.84 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 26 (Table 8). This optimal management regime will generate the maximum SEV of $1,425.43 (Table 16), with a NPW of $1,223.17 per acre (Table 12). This financially optimal rotation would produce an estimated 35.20 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 26.79 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 8). This optimal management regime will generate the maximum SEV of $724.77 (Table 16), with a NPW of $651.19 per acre (Table 12). This financially optimal rotation would produce an estimated 28.25 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 23.38 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 8). This optimal management regime will generate the maximum SEV of $360.55 (Table 16), with a NPW of $333.54 per acre (Table 12). This financially optimal rotation would

produce an estimated 23.72 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 20.94 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 8). This optimal management regime will generate the maximum SEV of $147.45 (Table 16), with a NPW of $140.63 per acre (Table 12). This financially optimal rotation would produce an estimated 23.72 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 20.94 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 32 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 37 (Table 8). This optimal management regime will generate the maximum SEV of $10,689.65 (Table 16), with a NPW of $6,506.95 per acre (Table 12). This financially optimal rotation would produce an estimated 64.77 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 39.89 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 20 percent of

basal area removed) and a final harvest is conducted at stand age 36 (Table 8). This optimal management regime will generate the maximum SEV of $3,988.68 (Table 16), with a NPW of $3,332.79 per acre (Table 12). This financially optimal rotation would produce an estimated 62.16 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 39.05 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 31 (Table 8). This optimal management regime will generate the maximum SEV of $2,019.62 (Table 16), with a NPW of $1,820.01 per acre (Table 12). This financially optimal rotation would produce an estimated 48.30 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 34.71 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 22 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 8). This optimal management regime will generate the maximum SEV of $1,168.77 (Table 16), with a NPW of $1,087.73 per acre (Table 12). This financially optimal rotation would produce an estimated 38.84 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 30.58 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 22 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 8). This optimal management regime will generate the maximum SEV of $711.08 (Table 16), with a NPW of $684.79 per acre (Table 12). This financially optimal rotation would produce an estimated 38.84 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 30.58 net tons of carbon per acre during one rotation (Table 4).

Western hemlock, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 22 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 8). This optimal management regime will generate the maximum SEV of $433.19 (Table 16), with a NPW of $424.54 per acre (Table 12). This financially optimal rotation would produce an estimated 38.84 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 30.58 net tons of carbon per acre during one rotation (Table 4).

White ash (*Fraxinus americana*)

Biological Information

White ash is the most common and useful native ash but it is almost never dominant in naturally regenerated forests. Its best growth occurs on moderately well drained soils in which the roots can penetrate to a depth of 16 inches or more. The range of white ash extends throughout the eastern United States from northern Florida, west to eastern Texas, north to eastern Minnesota, then northeast to Nova Scotia (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/fraxinus/americana.htm. May 3, 2006) (Fig. 1).

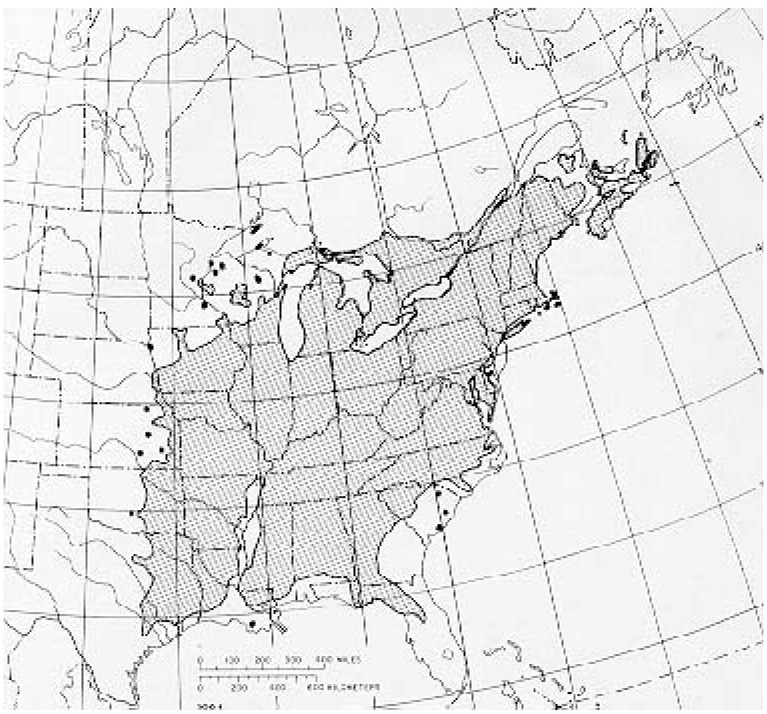

Fig. 1. The native range of white ash (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/fraxinus/americana.htm. May 3, 2006)

The height range of white ash at maturity is typically from 80 to 120 feet with a d.b.h. of 2 to 5 feet (http://www.hardwood.org/species_guide/display_species.asp?species=ash. May 4, 2006). Site indices ranging from 40 to 90 feet on base age 50 curves are not uncommon (Carmean et al., 1989). With even slight crowding in forest conditions, it produces a long, clear, straight bole with a fine-branched crown. Fully stocked stands exhibit excellent self-pruning, with shade killed branches dropping within 1 to 5 years. In mixed species stands diameter growth can range from 0.1 to 0.3 inches per year depending on individual tree and site quality (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/fraxinus/americana.htm. May 3, 2006).

White ash is a pioneer species that is often found on abandoned agricultural fields. During the seedling stage, it is considered shade tolerant, but with increasing age it becomes less tolerant, and is classed overall as intolerant. Dominant and codominant white ash responds well in both diameter and height growth to thinning, due to swift crown expansion (within a few years)(USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/fraxinus/americana.htm. May 3, 2006).

White ash is a versatile wood and has been utilized for a variety of uses. It has been used for furniture, flooring, doors, millwork and molding, kitchen cabinets, paneling, tool handles, baseball bats, hockey sticks, billiard cues, skis, oars and turnings (http://www.hardwood.org/species_guide/display_species.asp?species=ash. May 4, 2006). The winged seeds are utilized as food by a variety of birds. Variants of the species have also been breed for use specifically as ornamentals (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/fraxinus/americana.htm. May 3, 2006).

Economic Background

Howard and Chase (1995) summarized Maine stumpage price trends and analyzed both historic nominal and real price trends. Future prices depend upon both the supply and demand for timber, yet decision makers often base expectations on historic stumpage price trends. Howard and Chase determined that the real price of ash sawlogs had generally appreciated between 1963 and 1990 (rate = 0.033), while real pulpwood prices generally remained constant (rate = 0.006). Both veneer and boltwood material showed significant gains in real prices during the study period (rate = 0.033 and 0.023 respectively).

Grisez and Mendel (1972) determined the rate of value increase for white ash. Three components, the present value of the tree, future value of the tree, and the time period of interest determine the rate of value increase. Using the financial maturity concept, trees should be viewed as capital investments and liquidated when yield falls below an acceptable alternative rate of return. The data indicate that at an alternative rate of return of 6% for butt-log grades 1 and 2, financial maturity is reached at 14 to 16 inches diameter at breast height (dbh). This holds true as long as there is no improvement in log grades.

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Species___white ash_________ Region______Central States_________________

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 7.60, 8.90, and 10.20 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 25 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183482143 and 0.446428571, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Myers et al (1980) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$Y = 0.10491D^{2.23978}H^{0.80092}$$

where:

Y = the green weight of the total tree (lb.)

D = diameter at breast height (in.)

H = total tree height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $92/mbf (International 1/4) (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005) and pulpwood price was assumed to be $16/cord (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of white ash plantations in the Central States.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$130.8	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]The seedling cost was estimated based on the seedling prices from Minnesota DNR State Forest Nursery (http://www.dnr.state.mn.us/forestry/nurseries/pricelist.html. January 18, 2006) and Lee's Nursery, Inc. (http://www.leenursery.com/Seedling2006Catalog.pdf. January 18, 2006).

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Table 1. Total tons of carbon sequestered per acre for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	23.86	22.31	19.59	19.38	19.38	19.38
80	28.32	23.77	21.07	20.75	20.75	20.75
90	31.12	27.92	24.56	22.50	22.50	22.50

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	23.91	23.91	23.17	19.94	19.59	19.59
80	28.56	28.43	25.08	25.08	21.33	20.98
90	32.29	29.37	26.93	25.57	22.83	23.09

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	26.17	25.45	25.45	25.45	25.45	22.19
80	28.88	28.88	28.88	28.56	28.56	21.31
90	31.99	31.99	31.99	31.99	31.99	30.01

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	26.39	25.67	25.67	25.67	25.67	21.98
80	29.14	29.14	29.14	29.14	25.34	25.34
90	31.99	31.99	31.99	31.99	31.99	23.59

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
Site Index[1]						
70	<54-73-**81**[2]>[3] (25%)[4]	<42-72-**79**> (30%)	<42-51-**69**> (30%)	<41-49-**69**> (30%)	<41-49-**69**> (30%)	<41-49-**69**> (30%)
80	<49-71-**87**> (25%)	<40-70-**75**> (30%)	<39-44-**68**> (30%)	<39-44-**67**> (30%)	<39-44-**67**> (30%)	<39-44-**67**> (30%)
90	<41-74-**90**> (30%)	<40-68-**80**> (30%)	<39-46-**72**> (30%)	<38-43-**66**> (30%)	<38-43-**66**> (30%)	<38-43-**66**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	55-73-**81**[2] (25%)[3]	<55-73-**81**>[4] (25%)	<55-72-**79**> (30%)	<42-51-**70**> (30%)	<42-51-**69**> (30%)	<42-51-**69**> (30%)
80	57-71-**88** (20%)	<51-71-**87**> (25%)	<51-70-**76**> (25%)	<51-70-**76**> (25%)	<39-46-**68**> (30%)	<39-46-**67**> (30%)
90	50-69-**90** (25%)	<50-69-**81**> (25%)	<50-69-**74**> (25%)	<40-68-**73**> (30%)	<40-46-**66**> (30%)	<40-46-**67**> (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	58-73-**89**[2] (25%)[3]	<58-73-**89**>[4] (20%)	<58-73-**89**> (20%)	<58-73-**89**> (20%)	<58-73-**89**> (20%)	<58-**83**> (20%)
80	57-71-**89** (20%)	57-71-**89** (20%)	<57-71-**89**> (20%)	<57-71-**88**> (20%)	<57-71-**88**> (20%)	<**87**>
90	57-70-**90** (20%)	57-70-**90** (20%)	<57-70-**90**> (20%)	<57-70-**90**> (20%)	<57-70-**90**> (20%)	<57-70-**83**> (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	58-73-**90**[2] (25%)[3]	58-73-**90** (20%)	<58-73-**90**>[4] (20%)	<58-73-**90**> (20%)	<58-73-**90**> (20%)	<77-**90**> (20%)
80	57-71-**90** (20%)	57-71-**90** (20%)	<57-71-**90**> (20%)	<57-71-**90**> (20%)	<73-**90**> (25%)	<73-**90**> (25%)
90	57-70-**90** (20%)	57-70-**90** (20%)	<57-70-**90**> (20%)	<57-70-**90**> (20%)	<57-70-**90**> (20%)	<**90**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$151.11	-$345.68	-$372.49	-$377.28	-$377.46	-$376.83
80	-$110.04	-$338.71	-$370.19	-$376.34	-$377.08	-$376.68
90	-$88.23	-$335.08	-$369.65	-$375.86	-$376.89	-$376.60

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$13.94	-$256.93	-$321.87	-$344.16	-$354.63	-$360.37
80	$82.33	-$240.76	-$313.02	-$339.18	-$351.12	-$357.82
90	$125.69	-$222.25	-$304.49	-$333.97	-$347.62	-$355.32

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$487.07	-$2.27	-$173.85	-$251.05	-$291.69	-$315.42
80	$620.26	$52.10	-$144.37	-$232.40	-$278.82	-$306.04
90	$721.40	$101.20	-$115.95	-$214.12	-$266.19	-$296.83

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$717.97	$123.06	-$101.78	-$205.90	-$261.27	-$293.73
80	$882.42	$194.07	-$62.34	-$180.77	-$243.91	-$281.05
90	$1,010.95	$259.67	-$24.01	-$156.07	-$226.83	-$268.62

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$174.10	-$352.80	-$374.86	-$377.76	-$377.56	-$376.85
80	-$124.17	-$347.22	-$372.72	-$376.91	-$377.21	-$376.71
90	-$98.66	-$341.64	-$371.54	-$376.50	-$377.03	-$376.63

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$16.06	-$261.72	-$322.86	-$344.55	-$354.72	-$360.39
80	$92.61	-$244.09	-$314.21	-$339.41	-$351.23	-$357.85
90	$140.55	-$226.40	-$305.84	-$334.26	-$347.75	-$355.34

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$546.26	-$2.30	-$174.11	-$251.10	-$291.69	-$315.42
80	$695.63	$52.75	-$144.59	-$232.45	-$278.83	-$306.04
90	$806.68	$102.40	-$116.11	-$214.15	-$266.19	-$296.83

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the central United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$802.84	$124.53	-$101.92	-$205.94	-$261.27	-$293.73
80	$986.73	$196.39	-$62.43	-$180.80	-$243.91	-$281.05
90	$1,130.45	$262.77	-$24.04	-$156.10	-$226.83	-$268.62

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the central United States). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	54-73-**81**[3] (25%)[4]	785.66	0	541.82	2.60	1,280.69	12.51	2,608.17	15.11
	5.0%	42-72-**79** (30%)	607.48	0	631.82	3.03	1,184.54	11.12	2,423.84	14.15
	7.5%	42-51-**69** (30%)	607.48	0	673.45	0	1,722.47	7.51	3,003.40	7.51
	10.0%	41-49-**69** (30%)	557.72	0	578.25	0	1,731.04	7.51	2,867.01	7.51
	12.5%	41-49-**69** (30%)	557.72	0	578.25	0	1,731.04	7.51	2,867.01	7.51
	15.0%	41-49-**69** (30%)	557.72	0	578.25	0	1731.04	7.51	2,867.01	7.51
80	2.5%	49-71-**87** (25%)	719.36	0	643.67	2.59	1,368.76	17.59	2,731.79	20.18
	5.0%	40-70-**75** (30%)	578.64	0	736.46	3.00	1,447.83	10.76	2,762.93	13.76
	7.5%	39-44-**68** (30%)	561.43	0	563.79	0	2,008.63	8.08	3,133.85	8.08
	10.0%	39-44-**67** (30%)	561.43	0	563.79	0	2,017.82	7.58	3,143.04	7.58
	12.5%	39-44-**67** (30%)	561.43	0	563.79	0	2,017.82	7.58	3,143.04	7.58
	15.0%	39-44-**67** (30%)	561.43	0	563.79	0	2,017.82	7.58	3,143.04	7.58
90	2.5%	41-74-**90** (30%)	704.40	0	742.23	4.20	1,483.18	18.44	2,929.81	22.64
	5.0%	40-68-**80** (30%)	683.91	0	726.30	2.92	1,461.71	14.73	2,871.92	17.65
	7.5%	39-46-**72** (30%)	630.82	0	688.11	0	1,890.68	11.66	3,209.61	11.66
	10.0%	38-43-**66** (30%)	572.34	0	554.33	0	2,033.23	7.87	3,159.90	7.87
	12.5%	38-43-**66** (30%)	572.34	0	554.33	0	2,033.23	7.87	3,159.90	7.87
	15.0%	38-43-**66** (30%)	572.34	0	554.33	0	2,033.23	7.87	3,159.90	7.87

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 18. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the central United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	55-73-**81**[3] (25%)[4]	816.46	0	540.30	2.59	1,277.35	12.47	2,634.11	15.06
	5.0%	55-73-**81** (25%)	816.46	0	540.30	2.59	1,277.35	12.47	2,634.11	15.06
	7.5%	55-72-**79** (30%)	979.90	0	602.12	2.89	1,178.31	10.60	2,760.33	13.49
	10.0%	42-51-**70** (30%)	607.48	0	673.45	0	1,686.36	8.09	2,967.29	8.09
	12.5%	42-51-**69** (30%)	607.48	0	673.45	0	1,722.47	7.51	3,003.40	7.51
	15.0%	42-51-**69** (30%)	607.48	0	673.45	0	1,722.47	7.51	3,003.40	7.51
80	2.5%	57-71-**88** (20%)	751.29	0	519.62	2.12	1,479.12	18.61	2,750.03	20.73
	5.0%	57-71-**87** (25%)	754.33	0	640.35	2.57	1,363.04	17.51	2,757.72	20.08
	7.5%	51-70-**76** (25%)	754.33	0	623.89	2.38	1,584.20	11.96	2,962.42	14.34
	10.0%	51-70-**76** (25%)	754.33	0	623.89	2.38	1,584.20	11.96	2,962.42	14.34
	12.5%	39-46-**68** (30%)	561.43	0	607.83	0	2,007.63	8.07	3,179.89	8.07
	15.0%	39-46-**67** (30%)	561.43	0	607.83	0	2,016.78	7.58	3,186.04	7.58
90	2.5%	50-69-**90** (25%)	833.95	0	626.10	2.52	1,664.14	20.10	3,124.19	22.62
	5.0%	50-69-**81** (25%)	833.95	0	626.10	2.52	1,584.37	16.18	3,044.42	18.70
	7.5%	50-69-**74** (25%)	833.95	0	626.10	2.52	1,848.19	11.71	3,308.24	14.23
	10.0%	40-68-**73** (30%)	683.91	0	726.30	2.92	1,681.31	10.65	3,091.52	13.57
	12.5%	40-46-**66** (30%)	683.91	0	680.07	0	2,014.33	7.71	3,378.31	7.71
	15.0%	40-46-**67** (25%)	569.86	0	590.37	0	2,218.07	8.35	3,378.30	8.35

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 19. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the central United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	58-73-**89**[3] (25%)[4]	865.18	0	533.99	2.56	1,673.18	13.83	3,072.35	16.39
	5.0%	58-73-**89** (20%)	692.03	0	453.82	2.05	1,733.70	14.51	2,879.55	16.56
	7.5%	58-73-**89** (20%)	692.03	0	453.82	2.05	1,733.70	14.51	2,879.55	16.56
	10.0%	58-73-**89** (20%)	692.03	0	453.82	2.05	1,733.70	14.51	2,879.55	16.56
	12.5%	58-73-**89** (20%)	692.03	0	453.82	2.05	1,733.70	14.51	2,879.55	16.56
	15.0%	58-**83** (20%)	692.03	0	-[5]	-	1,552.39	14.89	2,244.42	14.89
80	2.5%	57-71-**89** (20%)	751.29	0	519.62	2.12	1,544.69	18.82	2,815.60	20.94
	5.0%	57-71-**89** (20%)	751.29	0	519.62	2.12	1,544.69	18.82	2,815.60	20.94
	7.5%	57-71-**89** (20%)	751.29	0	519.62	2.12	1,544.69	18.82	2,815.60	20.94
	10.0%	57-71-**88** (20%)	751.29	0	519.62	2.12	1,479.12	18.61	2,750.03	20.73
	12.5%	57-71-**88** (20%)	751.29	0	519.62	2.12	1,479.12	18.61	2,750.03	20.73
	15.0%	**87**	-	-	-	-	1,656.31	17.70	1,656.31	17.70
90	2.5%	57-70-**90** (20%)	775.93	0	525.63	2.11	1,741.91	20.47	3,043.47	22.58
	5.0%	57-70-**90** (20%)	775.93	0	525.63	2.11	1,741.91	20.47	3,043.47	22.58
	7.5%	57-70-**90** (20%)	775.93	0	525.63	2.11	1,741.91	20.47	3,043.47	22.58
	10.0%	57-70-**90** (20%)	775.93	0	525.63	2.11	1,741.91	20.47	3,043.47	22.58
	12.5%	57-70-**90** (20%)	775.93	0	525.63	2.11	1,741.91	20.47	3,043.47	22.58
	15.0%	57-70-**83** (20%)	775.93	0	525.63	2.11	1,656.35	17.70	2,957.91	19.81

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the central United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	58-73-**90**[3] (25%)[4]	865.18	0	533.99	2.56	1,756.42	14.00	3,155.59	16.56
	5.0%	58-73-**90** (20%)	692.03	0	453.82	2.05	1,799.51	14.68	2,945.36	16.73
	7.5%	58-73-**90** (20%)	692.03	0	453.82	2.05	1,799.51	14.68	2,945.36	16.73
	10.0%	58-73-**90** (20%)	692.03	0	453.82	2.05	1,799.51	14.68	2,945.36	16.73
	12.5%	58-73-**90** (20%)	692.03	0	453.82	2.05	1,799.51	14.68	2,945.36	16.73
	15.0%	77-**90** (20%)	443.88	2.13	-[5]	-	1,737.01	14.32	2,180.89	16.45
80	2.5%	57-71-**90** (20%)	751.29	0	519.62	2.12	1,640.36	19.03	2,911.27	21.15
	5.0%	57-71-**90** (20%)	751.29	0	519.62	2.12	1,640.36	19.03	2,911.27	21.15
	7.5%	57-71-**90** (20%)	751.29	0	519.62	2.12	1,640.36	19.03	2,911.27	21.15
	10.0%	57-71-**90** (20%)	751.29	0	519.62	2.12	1,640.36	19.03	2,911.27	21.15
	12.5%	73-**90** (25%)	644.06	2.56	-	-	1,532.20	17.99	2,176.26	20.55
	15.0%	73-**90** (25%)	644.06	2.56	-	-	1,532.20	17.99	2,176.26	20.55
90	2.5%	57-70-**90** (20%)	775.93	0	525.63	2.11	1,741.91	20.47	3,043.47	22.58
	5.0%	57-70-**90** (20%)	775.93	0	525.63	2.11	1,741.91	20.47	3,043.47	22.58
	7.5%	57-70-**90** (20%)	775.93	0	525.63	2.11	1,741.91	20.47	3,043.47	22.58
	10.0%	57-70-**90** (20%)	775.93	0	525.63	2.11	1,741.91	20.47	3,043.47	22.58
	12.5%	57-70-**90** (20%)	775.93	0	525.63	2.11	1,741.91	20.47	3,043.47	22.58
	15.0%	**90**	-	-	-	-	1,741.98	20.28	1,741.98	20.28

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for white ash plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	<54-73-**81**[2]>[3] (25%)[4]	55-73-**81** (25%)	0%	58-73-**89** (25%)	10%	58-73-**90** (25%)	11%
	80	<49-71-**87**> (25%)	57-71-**88** (20%)	1%	57-71-**89** (20%)	2%	57-71-**90** (20%)	3%
	90	<41-74-**90**> (30%)	50-69-**90** (25%)	0%	57-70-**90** (20%)	0%	57-70-**90** (20%)	0%
5.00%	70	<42-72-**79**> (30%)	<55-73-**81**> (25%)	3%	<58-73-**89**> (20%)	13%	58-73-**90** (20%)	14%
	80	<40-70-**75**> (30%)	<51-71-**87**> (25%)	16%	57-71-**89** (20%)	19%	57-71-**90** (20%)	20%
	90	<40-68-**80**> (30%)	<50-69-**81**> (25%)	1%	57-70-**90** (20%)	13%	57-70-**90** (20%)	13%
7.50%	70	<42-51-**69**> (30%)	<55-72-**79**> (30%)	14%	<58-73-**89**> (20%)	29%	<58-73-**90**> (20%)	30%
	80	<39-44-**68**> (30%)	<51-70-**76**> (25%)	12%	<57-71-**89**> (20%)	31%	<57-71-**90**> (20%)	32%
	90	<39-46-**72**> (30%)	<50-69-**74**> (25%)	3%	<57-70-**90**> (20%)	25%	<57-70-**90**> (20%)	25%
10.00%	70	<41-49-**69**> (30%)	<42-51-**70**> (30%)	1%	<58-73-**89**> (20%)	29%	<58-73-**90**> (20%)	30%
	80	<39-44-**67**> (30%)	<51-70-**76**> (25%)	13%	<57-71-**88**> (20%)	31%	<57-71-**90**> (20%)	34%
	90	<38-43-**66**> (30%)	<40-68-**73**> (30%)	11%	<57-70-**90**> (20%)	36%	<57-70-**90**> (20%)	36%
12.50%	70	<41-49-**69**> (30%)	<42-51-**69**> (30%)	0%	<58-73-**89**> (20%)	29%	<58-73-**90**> (20%)	30%
	80	<39-44-**67**> (30%)	<39-46-**68**> (30%)	1%	<57-71-**88**> (20%)	31%	<73-**90**> (25%)	34%
	90	<38-43-**66**> (30%)	<40-46-**66**> (30%)	0%	<57-70-**90**> (20%)	36%	<57-70-**90**> (20%)	36%
15.00%	70	<41-49-**69**> (30%)	<42-51-**69**> (30%)	0%	<58-**83**> (20%)	20%	<77-**90**> (20%)	30%
	80	<39-44-**67**> (30%)	<39-46-**67**> (30%)	0%	<**87**>	30%	<73-**90**> (25%)	34%
	90	<38-43-**66**> (30%)	<40-46-**67**> (25%)	2%	<57-70-**83**> (20%)	26%	<**90**>	36%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for white ash plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	-174.10	16.06		546.26		802.84	
	80	-124.17	92.61		695.63		986.73	
	90	-98.66	140.55		806.68		1,130.45	
5.00%	70	-352.80	-261.72		-2.30		124.53	
	80	-347.22	-244.09		52.75		196.39	
	90	-341.64	-226.40		102.40		262.77	
7.50%	70	-374.86	-322.86		-174.11		-101.92	
	80	-372.72	-314.21		-144.59		-62.43	
	90	-371.54	-305.84		-116.11		-24.04	
10.00%	70	-377.76	-344.55		-251.10		-205.94	
	80	-376.91	-339.41		-232.45		-180.80	
	90	-376.50	-334.26		-214.15		-156.10	
12.50%	70	-377.56	-354.72		-291.69		-261.27	
	80	-377.21	-351.23		-278.83		-243.91	
	90	-377.03	-347.75		-266.19		-226.83	
15.00%	70	-376.85	-360.39		-315.42		-293.73	
	80	-376.71	-357.85		-306.04		-281.05	
	90	-376.63	-355.34		-296.83		-268.62	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>Central States- White ash - Timber Only Rotations (C = $0/ton)</u>

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 54 and 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 5). This optimal management regime will generate the maximum SEV of -$174.10 (Table 13), with a NPW of -$151.11 per acre (Table 9). This means that -$174.10 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$151.11 per acre for managing one rotation, or -$174.10 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,608.17 cubic feet of pulpwood and 15.11 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.86 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 72 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 5). This optimal management regime will generate the maximum SEV of -$352.80 (Table 13), with a NPW of -$345.68 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,423.84 cubic feet of pulpwood and 14.15 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.31 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 5). This optimal management regime will generate the maximum SEV of -$374.86 (Table 13), with a NPW of -$372.49 per acre (Table 9). This financially optimal rotation would produce an estimated 3,003.40 cubic feet of pulpwood and 7.51 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.59 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 5). This optimal management regime will generate the maximum SEV of -$377.76 (Table 13), with a NPW of -$377.28 per acre (Table 9). This financially optimal rotation would produce an estimated 2,867.01 cubic feet of pulpwood and 7.51 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.38 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 5). This optimal management regime will generate the maximum SEV of -$377.56 (Table 13), with a NPW of -$377.46 per acre (Table 9). This financially optimal rotation would produce an estimated 2,867.01 cubic feet of pulpwood and 7.51 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.38 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 5). This optimal management regime will generate the maximum SEV of -$376.85 (Table 13), with a NPW of -$376.83 per acre (Table 9). This financially optimal rotation would produce an estimated 2,867.01 cubic feet of pulpwood and 7.51 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 19.38 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 49 and 71 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 5). This optimal management regime will generate the maximum SEV of -$124.17 (Table 13), with a NPW of -$110.04 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,731.79 cubic feet of pulpwood and 20.18 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 28.32 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 70 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 5). This optimal management regime will generate the maximum SEV of -$347.22 (Table 13), with a NPW of -$338.71 per acre (Table 9). This financially optimal rotation would produce an estimated 2,762.93 cubic feet of pulpwood and 13.76 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.77 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 5). This optimal management regime will generate the maximum SEV of -$372.72 (Table 13), with a NPW of -$370.19 per acre (Table 9). This financially optimal rotation would produce an estimated 3,133.85 cubic feet of pulpwood and 8.08 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 21.07 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 5). This optimal management regime will generate the maximum SEV of -$376.91 (Table 13), with a NPW of -$376.34 per acre (Table 9). This financially optimal rotation would produce an estimated 3,143.04 cubic feet of pulpwood and 7.58 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 20.75 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 5). This optimal management regime will generate the maximum SEV of -$377.21 (Table 13), with a NPW of -$377.08 per acre (Table 9). This financially optimal rotation would produce an estimated 3,143.04 cubic feet of pulpwood and 7.58 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 20.75 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 5). This optimal management regime will generate the maximum SEV of -$376.71 (Table 13), with a NPW of -$376.68 per acre (Table 9). This financially optimal rotation would

produce an estimated 3,143.04 cubic feet of pulpwood and 7.58 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 20.75 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 74 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$98.66 (Table 13), with a NPW of -$88.23 per acre (Table 9). This financially optimal rotation would produce an estimated 2,929.81 cubic feet of pulpwood and 22.64 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 31.12 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 68 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 5). This optimal management regime will generate the maximum SEV of -$341.64 (Table 13), with a NPW of -$335.08 per acre (Table 9). This financially optimal rotation would produce an estimated 2,871.92 cubic feet of pulpwood and 17.65 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 27.92 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 72 (Table 5). This optimal management regime will generate the maximum SEV of -$371.54 (Table 13), with a NPW of -$369.65 per acre (Table 9). This financially optimal rotation would produce an estimated 3,209.61 cubic feet of pulpwood and 11.66 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 24.56 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 43 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 5). This optimal management regime will generate the maximum SEV of -$376.50 (Table 13), with a NPW of -$375.86 per acre (Table 9). This financially optimal rotation would produce an estimated 3,159.90 cubic feet of pulpwood and 7.87 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.50 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 43 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 5). This optimal management regime will generate the maximum SEV of -$377.03 (Table 13), with a NPW of -$376.89 per acre (Table 9). This financially optimal rotation would

produce an estimated 3,159.90 cubic feet of pulpwood and 7.87 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.50 net tons of carbon per acre during one rotation (Table 1).

White ash, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 43 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 5). This optimal management regime will generate the maximum SEV of -$376.63 (Table 13), with a NPW of -$376.60 per acre (Table 9). This financially optimal rotation would produce an estimated 3,159.90 cubic feet of pulpwood and 7.87 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.50 net tons of carbon per acre during one rotation (Table 1).

<u>Central States- White ash - Timber + Carbon Rotations (C = $10/ton)</u>

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 55 and 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 6). This optimal management regime will generate the maximum SEV of $16.06 (Table 14), with a NPW of $13.94 per acre (Table 10). This means that $16.06 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $13.94 per acre for managing one rotation, or $16.06 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,634.11 cubic feet of pulpwood and 15.06 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.91 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 55 and 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 6). This optimal management regime will generate the maximum SEV of -$261.72 (Table 14), with a NPW of -$256.93 per acre (Table 10). This financially optimal rotation would produce an estimated 2,634.11 cubic feet of pulpwood and 15.06 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.91 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 55 and 72 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 6). This optimal management regime will generate the maximum SEV of -$322.86 (Table 14), with a NPW of -$321.87 per acre (Table 10). This financially optimal rotation would produce an estimated 2,760.33 cubic feet of pulpwood and 13.49 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 23.17 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 70 (Table 6). This optimal management regime will generate the maximum SEV of -$344.55 (Table 14), with a NPW of -$344.16 per acre (Table 10). This financially optimal rotation would produce an estimated 2,967.29 cubic feet of pulpwood and 8.09 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.94 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 6). This optimal management regime will generate the maximum SEV of -$354.72 (Table 14), with a NPW of -$354.63 per acre (Table 10). This financially optimal rotation would produce an estimated 3,003.40 cubic feet of pulpwood and 7.51 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.59 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 51 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 69 (Table 6). This optimal management regime will generate the maximum SEV of -$360.39 (Table 14), with a NPW of -$360.37 per acre (Table 10). This financially optimal rotation would produce an estimated 3,003.40 cubic feet of pulpwood and 7.51 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 19.59 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 71 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 6). This optimal management regime will generate the maximum SEV of $92.61 (Table 14), with a NPW of $82.33 per acre (Table 10). This financially optimal rotation would produce an estimated 2,750.03 cubic feet of pulpwood and 20.73 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 28.56 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 71 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 6). This optimal management regime will generate the maximum SEV of -$244.09 (Table 14), with a NPW of -$240.76 per acre (Table 10). This financially optimal rotation would produce an estimated 2,757.72 cubic feet of pulpwood and 20.08 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 28.43 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 70 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 6). This optimal management regime will generate the maximum SEV of -$314.21 (Table 14), with a NPW of -$313.02 per acre (Table 10). This financially optimal rotation would produce an estimated 2,962.42 cubic feet of pulpwood and 14.34 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.08 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 51 and 70 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 6). This optimal management regime will generate the maximum SEV of -$339.41 (Table 14), with a NPW of -$339.18 per acre (Table 10). This financially optimal rotation would produce an estimated 2,962.42 cubic feet of pulpwood and 14.34 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.08 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 46 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 6). This optimal management regime will generate the maximum SEV of -$351.23 (Table 14), with a NPW of -$351.12 per acre (Table 10). This financially optimal rotation would produce an estimated 3,179.89 cubic feet of pulpwood and 8.07 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 21.33 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 6). This optimal management regime will generate the maximum SEV of -$357.85 (Table 14), with a NPW of -$387.82 per acre (Table 10). This financially optimal rotation would produce an estimated 3,186.04 cubic feet of pulpwood and 7.58 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 20.98 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 69 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of $140.55 (Table 14), with a NPW of $125.69 per acre (Table 10). This financially optimal rotation would produce an estimated 3,124.19 cubic feet of pulpwood and 22.62 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 32.29 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 69 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 6). This optimal management regime will generate the maximum SEV of -$226.40 (Table 14), with a NPW of -$222.25 per acre (Table 10). This financially optimal rotation could produce an estimated 3,044.42 cubic feet of pulpwood and 18.50 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 29.37 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 50 and 69 (with 25 percent of basal area removed) and a final harvest in conducted at stand age 74 (Table 6). This optimal management regime will generate the maximum SEV of -$305.84 (Table 14), with a NPW of -$304.49 per acre (Table 10). This financially optimal rotation would produce an estimated 3,308.24 cubic feet of pulpwood and 14.24 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.93 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 68 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 73 (Table 6). This optimal management regime will generate the maximum SEV of -$334.26 (Table 14), with a NPW of -$333.97 per acre (Table 10). This financially optimal rotation would produce an estimated 3,091.52 cubic feet of pulpwood and 13.57 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.57 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 66 (Table 6). This optimal management regime will generate the maximum SEV of -$347.75 (Table 14), with a NPW of -$347.62 per acre (Table 10). This financially optimal rotation would produce an estimated 3,378.31 cubic feet of pulpwood and 7.71 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.83 net tons of carbon per acre during one rotation (Table 2).

White ash, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 67 (Table 6). This optimal management regime will generate the maximum SEV of -$355.34 (Table 14), with a NPW of -$355.32 per acre (Table 10). This financially optimal rotation would produce an estimated 3,378.30 cubic feet of pulpwood and 8.35 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 23.09 net tons of carbon per acre during one rotation (Table 2).

Central States- White ash - Timber + Carbon Rotations (C = $37/ton)

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of $546.26 (Table 15), with a NPW of $487.07 per acre (Table 11). This means that $546.26 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $487.07 per acre for managing one rotation, or $546.26 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,072.35 cubic feet of pulpwood and 16.39 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.17 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 73 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of -$2.30 (Table 15), with a NPW of -$2.27 per acre (Table 11). This financially optimal rotation would produce an estimated 2,879.55 cubic feet of pulpwood and 16.56 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 25.45 net tons of carbon per acre during one rotation (Table 3).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of -$174.11 (Table 15), with a NPW of -$173.85 per acre (Table 11). This financially optimal rotation would produce an estimated 2,879.55 cubic feet of pulpwood and 16.56 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 25.45 net tons of carbon per acre during one rotation (Table 3).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of -$251.10 (Table 15), with a NPW of -$251.05 per acre (Table 11). This financially optimal rotation would produce an estimated 2,879.55 cubic feet of pulpwood and 16.56 MBF of sawlogs

per acre from the thinning and final harvest (Table 19), and sequester 25.45 net tons of carbon per acre during one rotation (Table 3).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of -$291.69 (Table 15), with a NPW of -$291.69 per acre (Table 11). This financially optimal rotation would produce an estimated 2,879.55 cubic feet of pulpwood and 16.56 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 25.45 tons of carbon per acre during the rotation (Table 3).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 58 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 7). This optimal management regime will generate the maximum SEV of -$315.42 (Table 15), with a NPW of -$315.42 per acre (Table 11). This financially optimal rotation would produce an estimated 2,244.42 cubic feet of pulpwood and 14.89 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 22.19 tons of carbon per acre during the rotation (Table 3).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 71 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of $695.93 (Table 15), with a NPW of $620.26 per acre (Table 11). This financially optimal rotation would produce an estimated 2,815.60 cubic feet of pulpwood and 20.94 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 28.88 net tons of carbon per acre during one rotation (Table 3).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 71 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of $52.75 (Table 15), with a NPW of $52.10 per acre (Table 11). This financially optimal rotation would produce an estimated 2,815.60 cubic feet of pulpwood and 20.94 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 28.88 net tons of carbon per acre during one rotation (Table 3).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 71 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of -$144.59 (Table 15), with a NPW of -$144.37 per acre (Table 11). This financially optimal rotation would produce an estimated 2,851.60 cubic feet of pulpwood and 20.94 MBF of sawlogs

per acre from the thinning and final harvest (Table 19), and sequester 28.88 net tons of carbon per acre during one rotation (Table 3).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 71 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 7). This optimal management regime will generate the maximum SEV of -$232.45 (Table 15), with a NPW of -$232.40 per acre (Table 11). This financially optimal rotation would produce an estimated 2,750.03 cubic feet of pulpwood and 20.73 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 28.56 net tons of carbon per acre during one rotation (Table 3).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 71 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 7). This optimal management regime will generate the maximum SEV of -$278.83 (Table 15), with a NPW of -$278.82 per acre (Table 11). This financially optimal rotation would produce an estimated 2,750.03 cubic feet of pulpwood and 20.73 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 28.56 net tons of carbon per acre during one rotation (Table 3).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 87 (Table 7). This

optimal management regime will generate the maximum SEV of -$306.04 (Table 15), with a NPW of -$306.04 per acre (Table 11). This financially optimal rotation would produce an estimated 1,656.31 cubic feet of pulpwood and 17.70 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 21.31 net tons of carbon per acre during one rotation (Table 3).

White ash, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $806.68 (Table 15), with a NPW of $721.40 per acre (Table 11). This financially optimal rotation would produce an estimated 3,043.47 cubic feet of pulpwood and 22.58 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 31.99 net tons of carbon per acre during one rotation (Table 3).

White ash, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $102.40 (Table 15), with a NPW of $101.20 per acre (Table 11). This financially optimal rotation would produce an estimated 3,043.47 cubic feet of pulpwood and 22.58 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 31.99 net tons of carbon per acre during one rotation (Table 3).

White ash, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$116.11 (Table 15), with a NPW of -$115.95 per acre (Table 11). This financially optimal rotation would produce an estimated 3,043.47 cubic feet of pulpwood and 22.58 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 31.99 net tons of carbon per acre during one rotation (Table 3).

White ash, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$214.15 (Table 15), with a NPW of -$214.12 per acre (Table 11). This financially optimal rotation would produce an estimated 3,043.47 cubic feet of pulpwood and 22.58 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 31.99 net tons of carbon per acre during one rotation (Table 3).

White ash, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$266.19 (Table

15), with a NPW of -$266.19 per acre (Table 11). This financially optimal rotation would produce an estimated 3,043.47 cubic feet of pulpwood and 22.58 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 31.99 tons of carbon per acre during one rotation (Table 3).

White ash, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 7). This optimal management regime will generate the maximum SEV of -$296.83 (Table 15), with a NPW of -$296.83 per acre (Table 11). This financially optimal rotation would produce an estimated 2,957.91 cubic feet of pulpwood and 19.81 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 30.01 net tons of carbon per acre during one rotation (Table 3).

<u>Central States- White ash - Timber + Carbon Rotations (C = $50/ton)</u>

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $802.84 (Table 16), with a NPW of $717.97 per acre (Table 12). This means that $802.84 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $717.97 per acre for managing one rotation, or $802.84 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,155.59 cubic feet of pulpwood and 16.56 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 26.39 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $124.53 (Table 16), with a NPW of $123.06 per acre (Table 12). This financially optimal rotation would produce an estimated 2,945.36 cubic feet of pulpwood and 16.73 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.67 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$101.92 (Table 16), with a NPW of -$101.78 per acre (Table 12). This financially optimal rotation

would produce an estimated 2,945.36 cubic feet of pulpwood and 16.73 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.67 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$205.94 (Table 16), with a NPW of -$205.90 per acre (Table 12). This financially optimal rotation would produce an estimated 2,945.36 cubic feet of pulpwood and 16.73 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.67 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 73 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$261.27 (Table 16), with a NPW of -$261.27 per acre (Table 12). This financially optimal rotation would produce an estimated 2,945.36 cubic feet of pulpwood and 16.73 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.67 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 77 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$293.73 (Table 16), with a NPW of -$293.73 per acre (Table 12). This financially optimal rotation would produce an estimated 2,180.89 cubic feet of pulpwood and 16.45 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 21.98 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 71 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $986.73 (Table 16), with a NPW of $882.42 per acre (Table 12). This financially optimal rotation would produce an estimated 2,911.27 cubic feet of pulpwood and 21.15 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.14 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57and 71 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $196.39 (Table 16), with a NPW of $194.07 per acre (Table 12). This financially optimal rotation would

produce an estimated 2,911.27 cubic feet of pulpwood and 21.15 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.14 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57and 71 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$62.43 (Table 16), with a NPW of -$62.34 per acre (Table 12). This financially optimal rotation would produce an estimated 2,911.27 cubic feet of pulpwood and 21.15 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.14 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57and 71 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$180.80 (Table 16), with a NPW of -$180.77 per acre (Table 12). This financially optimal rotation would produce an estimated 2,911.27 cubic feet of pulpwood and 21.15 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.14 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$243.91 (Table 16), with a NPW of -$243.91 per acre (Table 12). This financially optimal rotation would produce an estimated 2,176.26 cubic feet of pulpwood and 20.55 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.34 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 73 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$281.05 (Table 16), with a NPW of -$281.05 per acre (Table 12). This financially optimal rotation would produce an estimated 2,176.26 cubic feet of pulpwood and 20.55 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.34 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $1,130.45 (Table 16), with a NPW of $1,010.95 per acre (Table 12). This financially optimal rotation

would produce an estimated 3,043.47 cubic feet of pulpwood and 22.58 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 31.99 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $262.77 (Table 16), with a NPW of $259.67 per acre (Table 12). This financially optimal rotation would produce an estimated 3,043.47 cubic feet of pulpwood and 22.58 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 31.99 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$24.04 (Table 16), with a NPW of -$24.01 per acre (Table 20). This financially optimal rotation would produce an estimated 3,043.47 cubic feet of pulpwood and 22.58 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 31.99 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$156.10 (Table 16), with a NPW of -$156.07 per acre (Table 12). This financially optimal rotation would produce an estimated 3,043.47 cubic feet of pulpwood and 22.58 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 31.99 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 70 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$226.83 (Table 16), with a NPW of -$226.83 per acre (Table 12). This financially optimal rotation would produce an estimated 3,043.47 cubic feet of pulpwood and 22.58 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 31.99 net tons of carbon per acre during one rotation (Table 4).

White ash, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$268.62 (Table 16), with a NPW of -$268.62 per acre (Table 12). This financially optimal rotation would produce an estimated 1,741.98 cubic feet of pulpwood and 20.28 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 23.59 net tons of carbon per acre during one rotation (Table 4).

Species white ash Region Lake States

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 4.30, 5.15, and 6.00 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 25 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183553598 and 0.489476260, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Perala and Alban (1994) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$Y = 0.01424D^{1.512}H^{1.1518}*1000$$

where:

Y = component dry-weight (kg.)

D = diameter at breast height (cm.)

H = height (cm.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $92/mbf (International 1/4) (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005) and pulpwood price was assumed to be $16/cord (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of white ash plantations in the Lake States.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$130.8	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]The seedling cost was estimated based on the seedling prices from Minnesota DNR State Forest Nursery (http://www.dnr.state.mn.us/forestry/nurseries/pricelist.html. January 18, 2006) and Lee's Nursery, Inc. (http://www.leenursery.com/Seedling2006Catalog.pdf. January 18, 2006).

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Table 23. Total tons of carbon sequestered per acre for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	19.00	19.00	18.68	18.68	18.68	18.68
80	23.50	22.73	22.73	22.44	22.44	22.44
90	27.91	26.96	26.63	26.63	26.63	26.54

[1]Base age 50.

Table 24. Total tons of carbon sequestered per acre for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	19.00	19.00	19.11	19.01	18.68	18.68
80	23.50	23.32	22.86	22.73	22.73	22.44
90	26.06	26.06	26.97	26.97	26.97	26.90

[1]Base age 50.

Table 25. Total tons of carbon sequestered per acre for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	19.24	19.24	19.25	16.05	16.05	16.05
80	23.36	23.55	23.23	19.55	19.55	19.55
90	26.06	25.97	27.38	23.25	23.25	23.25

[1]Base age 50.

Table 16. Total tons of carbon sequestered per acre for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	19.24	19.25	16.05	16.05	16.05	16.05
80	23.53	23.34	19.55	19.55	19.55	19.55
90	26.06	25.74	23.25	23.25	23.25	23.25

[1]Base age 50.

Table 27. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	<41-53-**89**[2]>[3] (30%)[4]	<41-53-**89**> (30%)	<40-53-**85**> (30%)	<40-53-**85**> (30%)	<40-53-**85**> (30%)	<40-53-**85**> (30%)
80	<40-49-**87**> (30%)	<40-45-**85**> (30%)	<40-45-**85**> (30%)	<40-45-**82**> (30%)	<40-45-**82**> (30%)	<40-45-**82**> (30%)
90	<38-47-**90**> (30%)	<38-47-**83**> (30%)	<38-44-**82**> (30%)	<38-44-**82**> (30%)	<38-44-**82**> (30%)	<37-44-**81**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 28. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	<41-53-**89**[2]>[3] (30%)[4]	<41-53-**89**> (30%)	<40-54-**89**> (30%)	<40-53-**88**> (30%)	<40-53-**85**> (30%)	<40-53-**85**> (30%)
80	<40-49-**87**> (30%)	<40-49-**86**> (30%)	<40-46-**85**> (30%)	<40-45-**85**> (30%)	<40-45-**85**> (30%)	<40-45-**82**> (30%)
90	42-**90** (30%)	<42-**90**> (30%)	<39-47-**83**> (30%)	<39-47-**83**> (30%)	<39-47-**83**> (30%)	<39-47-**82**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 29. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	45-54-**90**[2] (30%)[3]	66-71-**90** (30%)	<67-73-**90**>[4] (30%)	<**90**>	<**90**>	<**90**>
80	48-59-**88** (30%)	65-72-**90** (30%)	<69-76-**90**> (30%)	<**90**>	<**90**>	<**90**>
90	42-**90** (30%)	53-**90** (30%)	71-76-**90** (30%)	<**90**>	<**90**>	<**90**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 30. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	45-54-**90**[2] (30%)[3]	67-73-**90** (30%)	**90**	<**90**>[4]	<**90**>	<**90**>
80	60-66-**90** (30%)	68-73-**90** (30%)	**90**	<**90**>	<**90**>	<**90**>
90	42-**90** (30%)	57-**90** (30%)	**90**	**90**	<**90**>	<**90**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 31. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$266.57	-$365.08	-$377.32	-$378.38	-$377.70	-$376.88
80	-$252.76	-$360.15	-$375.86	-$377.79	-$377.47	-$376.79
90	-$236.75	-$356.07	-$374.36	-$377.21	-$377.21	-$376.66

[1]Base age 50.

Table 32. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$105.16	-$256.43	-$302.17	-$323.74	-$336.49	-$344.86
80	-$52.31	-$225.24	-$281.24	-$308.52	-$324.86	-$335.68
90	$105.88	-$187.77	-$258.62	-$291.96	-$312.16	-$325.63

[1]Base age 50.

Table 33. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$333.84	$42.81	-$94.99	-$174.33	-$224.43	-$258.06
80	$490.81	$151.08	-$18.92	-$118.18	-$181.40	-$224.10
90	$774.08	$270.53	$63.26	-$57.24	-$134.48	-$186.91

[1]Base age 50.

Table 34. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$546.42	$190.30	$6.06	-$101.93	-$170.32	-$216.22
80	$762.72	$336.09	$108.94	-$26.07	-$112.18	-$170.32
90	$1,095.82	$493.26	$220.06	$56.29	-$48.77	-$120.06

[1]Base age 50.

Table 35. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$298.97	-$369.66	-$378.48	-$378.48	-$377.71	-$376.89
80	-$285.23	-$365.65	-$376.61	-$377.92	-$377.49	-$376.79
90	-$264.74	-$362.08	-$375.29	-$377.35	-$377.23	-$376.67

[1]Base age 50.

Table 36. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$117.94	-$259.65	-$302.62	-$323.81	-$336.50	-$344.86
80	-$59.03	-$228.52	-$281.80	-$308.60	-$324.87	-$335.69
90	$118.39	-$190.02	-$259.21	-$292.05	-$312.17	-$325.63

[1]Base age 50.

Table 37. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$373.31	$43.32	-$95.12	-$174.36	-$224.43	-$258.07
80	$552.13	$152.88	-$18.95	-$118.20	-$181.41	-$224.10
90	$865.59	$273.75	$63.34	-$57.25	-$134.49	-$186.91

[1]Base age 50.

Table 38. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Lakes States region of the United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$611.01	$192.57	$6.07	-$101.95	-$170.32	-$216.22
80	$852.88	$340.10	$109.09	-$26.07	-$112.18	-$170.33
90	$1,225.35	$499.15	$220.37	$56.30	-$48.77	-$120.06

[1]Base age 50.

Table 39. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the Lakes States region of the United States. (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	41-53-**89**[3] (30%)[4]	593.60	0	640.17	0	1,728.60	7.08	2,962.37	7.08
	5.0%	41-53-**89** (30%)	593.60	0	640.17	0	1,728.60	7.08	2,962.37	7.08
	7.5%	40-53-**85** (30%)	553.48	0	643.22	0	1,953.63	5.52	3,150.33	5.52
	10.0%	40-53-**85** (30%)	553.48	0	643.22	0	1,953.63	5.52	3,150.33	5.52
	12.5%	40-53-**85** (30%)	553.48	0	643.22	0	1,953.63	5.52	3,150.33	5.52
	15.0%	40-53-**85** (30%)	553.48	0	643.22	0	1,953.63	5.52	3,150.33	5.52
80	2.5%	40-49-**87** (30%)	592.10	0	624.42	0	2,107.27	7.27	3,323.79	7.27
	5.0%	40-45-**85** (30%)	592.10	0	564.87	0	2,039.62	7.01	3,196.59	7.01
	7.5%	40-45-**85** (30%)	592.10	0	564.87	0	2,039.62	7.01	3,196.59	7.01
	10.0%	40-45-**82** (30%)	592.10	0	564.87	0	2,300.32	5.37	3,457.29	5.37
	12.5%	40-45-**82** (30%)	592.10	0	564.87	0	2,300.32	5.37	3,457.29	5.37
	15.0%	40-45-**82** (30%)	592.10	0	564.87	0	2,300.32	5.37	3,457.29	5.37
90	2.5%	38-47-**90** (30%)	635.96	0	682.10	0	2,129.87	9.00	3,447.93	9.00
	5.0%	38-47-**83** (30%)	635.96	0	682.10	0	2,273.76	6.87	3,591.82	6.87
	7.5%	38-44-**82** (30%)	635.96	0	562.46	0	2,319.21	6.58	3,517.63	6.58
	10.0%	38-44-**82** (30%)	635.96	0	562.46	0	2,319.21	6.58	3,517.63	6.58
	12.5%	38-44-**82** (30%)	635.96	0	562.46	0	2,319.21	6.58	3,517.63	6.58
	15.0%	37-44-**81** (30%)	555.21	0	567.93	0	2,408.75	6.03	3,531.89	6.03

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 40. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the Lakes States region of the United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	41-53-**89**[3] (30%)[4]	593.60	0	640.17	0	1,728.60	7.08	2,962.37	7.08
	5.0%	41-53-**89** (30%)	593.60	0	640.17	0	1,728.60	7.08	2,962.37	7.08
	7.5%	40-54-**89** (30%)	553.48	0	672.71	0	1,746.23	7.02	2,972.42	7.02
	10.0%	40-53-**88** (30%)	553.48	0	643.22	0	1,822.34	6.63	3,019.04	6.63
	12.5%	40-53-**85** (30%)	553.48	0	643.22	0	1,953.63	5.52	3,150.33	5.52
	15.0%	40-53-**85** (30%)	553.48	0	643.22	0	1,953.63	5.52	3,150.33	5.52
80	2.5%	40-49-**87** (30%)	592.10	0	624.42	0	2,107.27	7.27	3,323.79	7.27
	5.0%	40-49-**86** (30%)	592.10	0	624.42	0	2,077.53	7.14	3,294.05	7.14
	7.5%	40-46-**85** (30%)	592.10	0	580.67	0	2,055.95	6.95	3,228.72	6.95
	10.0%	40-45-**85** (30%)	592.10	0	564.87	0	2,039.62	7.01	3,196.59	7.01
	12.5%	40-45-**85** (30%)	592.10	0	564.87	0	2,039.62	7.01	3,196.59	7.01
	15.0%	40-45-**82** (30%)	592.10	0	564.87	0	2,300.32	5.37	3,457.29	5.37
90	2.5%	42-**90** (30%)	713.99	0	-[5]	-	2,973.77	6.57	3,687.76	6.57
	5.0%	42-**90** (30%)	713.99	0	-	-	2,973.77	6.57	3,687.76	6.57
	7.5%	39-47-**83** (30%)	674.99	0	675.93	0	2,280.21	6.81	3,631.13	6.81
	10.0%	39-47-**83** (30%)	674.99	0	675.93	0	2,280.21	6.81	3,631.13	6.81
	12.5%	39-47-**83** (30%)	674.99	0	675.93	0	2,280.21	6.81	3,631.13	6.81
	15.0%	39-47-**82** (30%)	674.99	0	675.93	0	2,362.71	6.26	3,713.63	6.26

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 41. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the Lakes States region of the United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	45-54-**90**[3] (30%)[4]	638.85	0	644.72	0	1,720.15	7.12	3,003.72	7.12
	5.0%	66-71-**90** (30%)	968.39	0	734.71	0	1,950.24	4.46	3,653.34	4.46
	7.5%	67-73-**90** (30%)	980.02	0	750.60	0	1999.36	4.08	3,729.98	4.08
	10.0%	**90**	-[5]	-	-	-	3,745.67	0	3,745.67	0
	12.5%	**90**	-	-	-	-	3,745.67	0	3,745.67	0
	15.0%	**90**	-	-	-	-	3,745.67	0	3,745.67	0
80	2.5%	48-59-**88** (30%)	784.81	0	775.22	0	1,967.08	6.77	3,527.11	6.77
	5.0%	65-72-**90** (30%)	1,044.86	0	839.97	0	2,099.01	5.13	3,983.84	5.13
	7.5%	69-76-**90** (30%)	1,104.36	0	853.03	0	2,178.98	4.03	4,136.37	4.03
	10.0%	**90**	-	-	-	-	3,965.81	0	3,965.81	0
	12.5%	**90**	-	-	-	-	3,965.81	0	3,965.81	0
	15.0%	**90**	-	-	-	-	3,965.81	0	3,965.81	0
90	2.5%	42-**90** (30%)	713.99	0	-	-	2,973.77	6.57	3,687.76	6.57
	5.0%	53-**90** (30%)	927.47	0	-	-	2,994.47	5.51	3,921.94	5.51
	7.5%	71-76-**90** (30%)	1,170.63	0	911.43	0	2,184.13	4.88	4,266.19	4.88
	10.0%	**90**	-	-	-	-	4,255.00	0	4,255.00	0
	12.5%	**90**	-	-	-	-	4,255.00	0	4,255.00	0
	15.0%	**90**	-	-	-	-	4,255.00	0	4,255.00	0

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 42. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the Lakes States region of the United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.5%	45-54-**90**[3] (30%)[4]	638.85	0	644.72	0	1,720.15	7.12	3,003.72	7.12
	5.0%	67-73-**90** (30%)	980.02	0	750.60	0	1,999.36	4.08	3,729.98	4.08
	7.5%	**90**	-[5]-	-	-	-	3,745.67	0	3,745.67	0
	10.0%	**90**	-	-	-	-	3,745.67	0	3,745.67	0
	12.5%	**90**	-	-	-	-	3,745.67	0	3,745.67	0
	15.0%	**90**	-	-	-	-	3,745.67	0	3,745.67	0
80	2.5%	60-66-**90** (30%)	908.79	0	796.04	0	1,907.34	6.53	3,612.17	6.53
	5.0%	68-73-**90** (30%)	1,086.85	0	832.78	0	2,127.21	4.67	4,046.84	4.67
	7.5%	**90**	-	-	-	-	3,965.81	0	3,965.81	0
	10.0%	**90**	-	-	-	-	3,965.81	0	3,965.81	0
	12.5%	**90**	-	-	-	-	3,965.81	0	3,965.81	0
	15.0%	**90**	-	-	-	-	3,965.81	0	3,965.81	0
90	2.5%	42-**90** (30%)	713.99	0	-	-	2,973.77	6.57	3,687.76	6.57
	5.0%	57-**90** (30%)	988.21	0	-	-	3,013.35	4.70	4,001.56	4.70
	7.5%	**90**	-	-	-	-	4,255.00	0	4,255.00	0
	10.0%	**90**	-	-	-	-	4,255.00	0	4,255.00	0
	12.5%	**90**	-	-	-	-	4,255.00	0	4,255.00	0
	15.0%	**90**	-	-	-	-	4,255.00	0	4,255.00	0

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 43. Financially optimal thinning and final harvest schedules for white ash plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	<41-53-**89**[2]>[3] (30%)[4]	<41-53-**89**> (30%)	0%	45-54-**90** (30%)	1%	45-54-**90** (30%)	1%
	80	<40-49-**87**> (30%)	<40-49-**87**> (30%)	0%	48-59-**88** (30%)	1%	60-66-**90** (30%)	3%
	90	<38-47-**90**> (30%)	42-**90** (30%)	0%	42-**90** (30%)	0%	42-**90** (30%)	0%
5.00%	70	<41-53-**89**> (30%)	<41-53-**89**> (30%)	0%	66-71-**90** (30%)	1%	67-73-**90** (30%)	1%
	80	<40-45-**85**> (30%)	<40-49-**86**> (30%)	1%	65-72-**90** (30%)	6%	68-73-**90** (30%)	6%
	90	<38-47-**83**> (30%)	<42-**90**> (30%)	8%	53-**90** (30%)	8%	57-**90** (30%)	8%
7.50%	70	<40-53-**85**> (30%)	<40-54-**89**> (30%)	5%	<67-73-**90**> (30%)	6%	**90**	6%
	80	<40-45-**85**> (30%)	<40-46-**85**> (30%)	0%	<69-76-**90**> (30%)	6%	**90**	6%
	90	<38-44-**82**> (30%)	<39-47-**83**> (30%)	1%	71-76-**90** (30%)	10%	**90**	10%
10.00%	70	<40-53-**85**> (30%)	<40-53-**88**> (30%)	4%	<**90**>	6%	<**90**>	6%
	80	<40-45-**82**> (30%)	<40-45-**85**> (30%)	4%	<**90**>	10%	<**90**>	10%
	90	<38-44-**82**> (30%)	<39-47-**83**> (30%)	1%	<**90**>	10%	**90**	10%
12.50%	70	<40-53-**85**> (30%)	<40-53-**85**> (30%)	0%	<**90**>	6%	<**90**>	6%
	80	<40-45-**82**> (30%)	<40-45-**85**> (30%)	4%	<**90**>	10%	<**90**>	10%
	90	<38-44-**82**> (30%)	<39-47-**83**> (30%)	1%	<**90**>	10%	<**90**>	10%
15.00%	70	<40-53-**85**> (30%)	<40-53-**85**> (30%)	0%	<**90**>	6%	<**90**>	6%
	80	<40-45-**82**> (30%)	<40-45-**82**> (30%)	0%	<**90**>	10%	<**90**>	10%
	90	<37-44-**81**> (30%)	<39-47-**82**> (30%)	1%	<**90**>	11%	<**90**>	11%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

[4]Number in parentheses indicates the percentage of basal area removed during thinning

Table 44. The soil expectation value ($/acre) of the financially optimal rotations for white ash plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	-298.97	-117.94		373.31		611.01	
	80	-285.23	-59.03		552.13		852.88	
	90	-264.74	118.39		865.59		1,225.35	
5.00%	70	-369.66	-259.65		43.32		192.57	
	80	-365.65	-228.52		152.88		340.10	
	90	-362.08	-190.02		273.75		499.15	
7.50%	70	-378.48	-302.62		-95.12		6.07	
	80	-376.61	-281.80		-18.95		109.09	
	90	-375.29	-259.21		63.34		220.37	
10.00%	70	-378.48	-323.81		-174.36		-101.95	
	80	-377.92	-308.60		-118.20		-26.07	
	90	-377.35	-292.05		-57.25		56.30	
12.50%	70	-377.71	-336.50		-224.43		-170.32	
	80	-377.49	-324.87		-181.41		-112.18	
	90	-377.23	-312.17		-134.49		-48.77	
15.00%	70	-376.89	-344.86		-258.07		-216.22	
	80	-376.79	-335.69		-224.10		-170.33	
	90	-376.67	-325.63		-186.91		-120.06	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

Lake States - White ash - Timber Only Rotations (C = $0/ton)

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 27). This optimal management regime will generate the maximum SEV of -$298.97 (Table 35), with a NPW of -$266.57 per acre (Table 31). This means that -$298.97 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$266.57 per acre for managing one rotation, or -$298.97 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,962.37 cubic feet of pulpwood and 7.08 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 19.00 net tons of carbon per acre during one rotation (Table 23). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 27). This optimal management regime will generate the maximum SEV of -$369.66 (Table 35), with a NPW of -$365.08 per acre (Table 31). This financially optimal

rotation would produce an estimated 2,962.37 cubic feet of pulpwood and 7.08 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 19.00 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 27). This optimal management regime will generate the maximum SEV of -$378.48 (Table 35), with a NPW of -$377.32 per acre (Table 31). This financially optimal rotation would produce an estimated 3,150.33 cubic feet of pulpwood and 5.52 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 18.68 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 27). This optimal management regime will generate the maximum SEV of -$378.48 (Table 35), with a NPW of -$378.38 per acre (Table 31). This financially optimal rotation would produce an estimated 3,150.33 cubic feet of pulpwood and 5.52 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 18.68 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 27). This optimal management regime will generate the maximum SEV of -$377.71 (Table 35), with a NPW of -$377.70 per acre (Table 31). This financially optimal rotation would produce an estimated 3,150.33 cubic feet of pulpwood and 5.52 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 18.38 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 27). This optimal management regime will generate the maximum SEV of -$376.89 (Table 35), with a NPW of -$376.88 per acre (Table 31). This financially optimal rotation would produce an estimated 3,150.33 cubic feet of pulpwood and 5.52 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 18.38 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 27). This optimal management regime will generate the maximum SEV of -$285.23 (Table 35), with a NPW of -$252.76 per acre (Table 31). This financially optimal

rotation would produce an estimated 3,323.79 cubic feet of pulpwood and 7.27 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 23.50 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 27). This optimal management regime will generate the maximum SEV of -$365.65 (Table 35), with a NPW of -$360.15 per acre (Table 31). This financially optimal rotation would produce an estimated 3,196.59 cubic feet of pulpwood and 7.01 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 22.73 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 37). This optimal management regime will generate the maximum SEV of -$376.61 (Table 35), with a NPW of -$375.86 per acre (Table 31). This financially optimal rotation would produce an estimated 3,196.59 cubic feet of pulpwood and 7.01 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 22.73 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 37). This optimal management regime will generate the maximum SEV of -$377.92 (Table 35), with a NPW of -$377.79 per acre (Table 31). This financially optimal rotation would produce an estimated 3,457.29 cubic feet of pulpwood and 5.37 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 22.44 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 27). This optimal management regime will generate the maximum SEV of -$377.49 (Table 35), with a NPW of -$377.47 per acre (Table 31). This financially optimal rotation would produce an estimated 3,457.29 cubic feet of pulpwood and 5.37 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 22.44 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 27). This optimal management regime will generate the maximum SEV of -$376.79 (Table 35), with a NPW of -$376.79 per acre (Table 31). This financially optimal

rotation would produce an estimated 3,457.29 cubic feet of pulpwood and 5.37 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 22.44 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 27). This optimal management regime will generate the maximum SEV of -$264.74 (Table 35), with a NPW of -$236.75 per acre (Table 31). This financially optimal rotation would produce an estimated 3,447.93 cubic feet of pulpwood and 9.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 27.91 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 27). This optimal management regime will generate the maximum SEV of -$362.08 (Table 35), with a NPW of -$356.07 per acre (Table 31). This financially optimal rotation would produce an estimated 3,591.82 cubic feet of pulpwood and 6.87 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 26.96 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 27). This optimal management regime will generate the maximum SEV of -$375.29 (Table 35), with a NPW of -$374.36 per acre (Table 31). This financially optimal rotation would produce an estimated 3,517.63 cubic feet of pulpwood and 6.58 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 26.63 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 27). This optimal management regime will generate the maximum SEV of -$377.35 (Table 35), with a NPW of -$377.21 per acre (Table 31). This financially optimal rotation would produce an estimated 3,517.63 cubic feet of pulpwood and 6.58 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 26.63 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 27). This optimal management regime will generate the maximum SEV of -$377.23 (Table 35), with a NPW of -$377.21 per acre (Table 31). This financially optimal

rotation would produce an estimated 3,517.63 cubic feet of pulpwood and 6.58 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 26.63 net tons of carbon per acre during one rotation (Table 23).

White ash, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 81 (Table 27). This optimal management regime will generate the maximum SEV of -$376.67 (Table 35), with a NPW of -$376.66 per acre (Table 31). This financially optimal rotation would produce an estimated 3,531.89 cubic feet of pulpwood and 6.03 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 26.54 net tons of carbon per acre during one rotation (Table 23).

<u>Lake States - White ash - Timber + Carbon Rotations (C = $10/ton)</u>

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 28). This optimal management regime will generate the maximum SEV of -$117.94 (Table 36), with a NPW of -$105.16 per acre (Table 32). This means that -$117.94 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on

every dollar invested plus -$105.16 per acre for managing one rotation, or -$117.94 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,962.37 cubic feet of pulpwood and 7.08 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 19.00 net tons of carbon per acre during one rotation (Table 24). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 28). This optimal management regime will generate the maximum SEV of -$259.65 (Table 36), with a NPW of -$256.43 per acre (Table 32). This financially optimal rotation would produce an estimated 2,962.37 cubic feet of pulpwood and 7.08 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 19.00 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 28). This optimal management regime will generate the maximum SEV of -$302.62 (Table 36), with a NPW of -$302.17 per acre (Table 32). This financially optimal rotation would produce an estimated 2,972.42 cubic feet of pulpwood and 7.02 MBF of

sawlogs per acre from the thinning and final harvest (Table 40), and sequester 19.11 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 28). This optimal management regime will generate the maximum SEV of -$323.81 (Table 36), with a NPW of -$223.74 per acre (Table 32). This financially optimal rotation would produce an estimated 3,019.04 cubic feet of pulpwood and 6.63 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 19.01 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 28). This optimal management regime will generate the maximum SEV of -$336.50 (Table 36), with a NPW of -$336.49 per acre (Table 32). This financially optimal rotation would produce an estimated 3,150.33 cubic feet of pulpwood and 5.52 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 18.68 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 53 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 28). This optimal management regime will generate the maximum SEV of -$344.86 (Table 36), with a NPW of -$344.86 per acre (Table 32). This financially optimal rotation would produce an estimated 3,150.33 cubic feet of pulpwood and 5.52 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 18.68 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 28). This optimal management regime will generate the maximum SEV of -$59.03 (Table 36), with a NPW of -$52.31 per acre (Table 32). This financially optimal rotation would produce an estimated 3,323.79 cubic feet of pulpwood and 7.27 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 23.50 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 86 (Table 28). This optimal management regime will generate the maximum SEV of -$228.52 (Table 36), with a NPW of -$225.24 per acre (Table 32). This financially optimal rotation would produce an estimated 3,294.05 cubic feet of pulpwood and 7.14 MBF of

sawlogs per acre from the thinning and final harvest (Table 40), and sequester 23.32 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 28). This optimal management regime will generate the maximum SEV of -$281.80 (Table 36), with a NPW of -$281.24 per acre (Table 32). This financially optimal rotation would produce an estimated 3,228.72 cubic feet of pulpwood and 6.95 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 22.86 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 28). This optimal management regime will generate the maximum SEV of -$324.87 (Table 36), with a NPW of -$324.86 per acre (Table 32). This financially optimal rotation would produce an estimated 3,196.59 cubic feet of pulpwood and 7.01 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 22.73 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 28). This optimal management regime will generate the maximum SEV of -$324.87 (Table 36), with a NPW of -$324.86 per acre (Table 32). This financially optimal rotation would produce an estimated 3,196.59 cubic feet of pulpwood and 7.01 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 22.73 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 45 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 28). This optimal management regime will generate the maximum SEV of -$335.69 (Table 36), with a NPW of -$335.68 per acre (Table 32). This financially optimal rotation would produce an estimated 3,457.29 cubic feet of pulpwood and 5.37 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 22.44 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 42 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of $118.39 (Table 36), with a NPW of $105.88 per acre (Table 32). This financially optimal rotation would produce an estimated 3,687.76 cubic feet of pulpwood and 6.57 MBF of sawlogs per acre

from the thinning and final harvest (Table 40), and sequester 26.06 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 42 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$190.02 (Table 36), with a NPW of -$187.77 per acre (Table 32). This financially optimal rotation could produce an estimated 3,687.76 cubic feet of pulpwood and 6.57 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 26.06 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 47 (with 30 percent of basal area removed) and a final harvest in conducted at stand age 83 (Table 28). This optimal management regime will generate the maximum SEV of -$259.21 (Table 36), with a NPW of -$258.62 per acre (Table 32). This financially optimal rotation would produce an estimated 3,631.13 cubic feet of pulpwood and 6.81 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 26.97 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 47 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 28). This optimal management regime will generate the maximum SEV of -$292.05 (Table 36), with a NPW of -$291.96 per acre (Table 32). This financially optimal rotation would produce an estimated 3,631.13 cubic feet of pulpwood and 6.81 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 26.97 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 83 (Table 28). This optimal management regime will generate the maximum SEV of -$312.17 (Table 36), with a NPW of -$312.16 per acre (Table 32). This financially optimal rotation would produce an estimated 3,631.13 cubic feet of pulpwood and 6.81 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 26.97 net tons of carbon per acre during one rotation (Table 24).

White ash, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 28). This optimal management regime will generate the maximum SEV of -$325.63 (Table 36), with a NPW of -$325.63 per acre (Table 32). This financially optimal rotation would produce an estimated 3,713.63 cubic feet of pulpwood and 6.26 MBF of

sawlogs per acre from the thinning and final harvest (Table 40), and sequester 26.90 net tons of carbon per acre during one rotation (Table 24).

<u>Lake States - White ash - Timber + Carbon Rotations (C = $37/ton)</u>

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of $373.31 (Table 37), with a NPW of $333.84 per acre (Table 33). This means that $373.31 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $333.84 per acre for managing one rotation, or $373.31 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,003.72 cubic feet of pulpwood and 7.12 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 19.24 net tons of carbon per acre during one rotation (Table 25). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 66 and 71 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of $43.32 (Table 37), with a NPW of $42.81 per acre (Table 33). This financially optimal rotation would produce an estimated 3,653.34 cubic feet of pulpwood and 4.46 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 19.24 net tons of carbon per acre during one rotation (Table 25).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 67 and 73 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$95.12 (Table 37), with a NPW of -$94.99 per acre (Table 33). This financially optimal rotation would produce an estimated 3,729.98 cubic feet of pulpwood and 4.08 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 19.25 net tons of carbon per acre during one rotation (Table 25).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$174.36 (Table 37), with a NPW of -$174.33 per acre (Table 33). This financially optimal rotation would produce an estimated 3,745.67 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 41), and sequester 16.05 net tons of carbon per acre during one rotation (Table 25).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$224.43 (Table 37), with a NPW of -$224.43 per acre (Table 33). This financially optimal rotation would produce an estimated 3,745.67 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 41), and sequester 16.05 tons of carbon per acre during the rotation (Table 25).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$258.07 (Table 37), with a NPW of -$258.06 per acre (Table 33). This financially optimal rotation would produce an estimated 3,745.67 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 41), and sequester 16.05 tons of carbon per acre during the rotation (Table 25).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 48 and 59 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 29). This optimal management regime will generate the maximum SEV of $552.13 (Table 37), with a NPW of $490.81 per acre (Table 33). This financially optimal rotation would produce an estimated 3,527.11 cubic feet of pulpwood and 6.77 MBF of sawlogs

per acre from the thinning and final harvest (Table 41), and sequester 23.36 net tons of carbon per acre during one rotation (Table 25).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 65 and 72 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of $152.88 (Table 37), with a NPW of $151.08 per acre (Table 33). This financially optimal rotation would produce an estimated 3,983.84 cubic feet of pulpwood and 5.13 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 23.55 net tons of carbon per acre during one rotation (Table 25).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 69 and 76 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$18.95 (Table 37), with a NPW of -$18.92 per acre (Table 33). This financially optimal rotation would produce an estimated 4,136.37 cubic feet of pulpwood and 4.03 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 23.23 net tons of carbon per acre during one rotation (Table 25).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This

optimal management regime will generate the maximum SEV of -$118.20 (Table 37), with a NPW of -$118.18 per acre (Table 33). This financially optimal rotation would produce an estimated 3,965.81 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 41), and sequester 19.55 net tons of carbon per acre during one rotation (Table 25).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$181.41 (Table 37), with a NPW of -$181.40 per acre (Table 33). This financially optimal rotation would produce an estimated 3,965.81 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 19.55 net tons of carbon per acre during one rotation (Table 25).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$224.10 (Table 37), with a NPW of -$224.10 per acre (Table 33). This financially optimal rotation would produce an estimated 3,965.81 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 41), and sequester 19.55 net tons of carbon per acre during one rotation (Table 25).

White ash, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 42 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of $865.59 (Table 37), with a NPW of $774.08 per acre (Table 33). This financially optimal rotation would produce an estimated 3,687.76 cubic feet of pulpwood and 6.57 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 26.06 net tons of carbon per acre during one rotation (Table 25).

White ash, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of $273.75 (Table 37), with a NPW of $270.53 per acre (Table 33). This financially optimal rotation would produce an estimated 3,921.94 cubic feet of pulpwood and 5.51 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 25.97 net tons of carbon per acre during one rotation (Table 25).

White ash, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 71 and 76 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of $63.34 (Table 37), with a NPW of $63.26 per acre (Table 33). This financially optimal rotation would produce

an estimated 4,266.19 cubic feet of pulpwood and 4.88 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 27.38 net tons of carbon per acre during one rotation (Table 25).

White ash, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$57.25 (Table 37), with a NPW of -$57.24 per acre (Table 33). This financially optimal rotation would produce an estimated 4,255.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 41), and sequester 23.25 net tons of carbon per acre during one rotation (Table 25).

White ash, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$134.49 (Table 37), with a NPW of -$134.48 per acre (Table 33). This financially optimal rotation would produce an estimated 4,255.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 23.25 tons of carbon per acre during one rotation (Table 25).

White ash, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$186.91 (Table 37),

with a NPW of -$186.91 per acre (Table 33). This financially optimal rotation would produce an estimated 4,255.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 41), and sequester 23.25 net tons of carbon per acre during one rotation (Table 25).

Lake States - White ash - Timber + Carbon Rotations (C = $50/ton)

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 54 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $611.01 (Table 38), with a NPW of $546.42 per acre (Table 34). This means that $611.01 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $546.42 per acre for managing one rotation, or $611.01 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,003.72 cubic feet of pulpwood and 7.12 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 19.24 net tons of carbon per acre during one rotation (Table 26). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 67 and 73 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $192.57 (Table 38), with a NPW of $190.30 per acre (Table 34). This financially optimal rotation would produce an estimated 3,729.98 cubic feet of pulpwood and 4.08 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 19.25 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $6.07 (Table 38), with a NPW of $6.06 per acre (Table 34). This financially optimal rotation would produce an estimated 3,745.67 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 16.05 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$101.95 (Table 38), with a NPW of -$101.93 per acre (Table 34). This financially optimal rotation would produce an estimated 3,745.67 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre

from the final harvest (Table 42), and sequester 16.05 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$170.32 (Table 38), with a NPW of -$170.32 per acre (Table 34). This financially optimal rotation would produce an estimated 3,745.67 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 16.05 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$216.22 (Table 38), with a NPW of -$216.22 per acre (Table 34). This financially optimal rotation would produce an estimated 3,745.67 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 16.05 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 60 and 66 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $852.88

(Table 38), with a NPW of $762.72 per acre (Table 34). This financially optimal rotation would produce an estimated 3,612.17 cubic feet of pulpwood and 6.53 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 23.53 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 68 and 73 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $340.10 (Table 38), with a NPW of $336.09 per acre (Table 34). This financially optimal rotation would produce an estimated 4,046.84 cubic feet of pulpwood and 4.67 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 23.34 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $109.09 (Table 38), with a NPW of $108.94 per acre (Table 34). This financially optimal rotation would produce an estimated 3,965.81 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 19.55 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$26.07 (Table 38), with a NPW of -$26.07 per acre (Table 34). This financially optimal rotation would produce an estimated 3,965.81 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 19.55 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$112.18 (Table 38), with a NPW of -$112.18 per acre (Table 34). This financially optimal rotation would produce an estimated 3,965.81 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 19.55 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$170.33 (Table 38), with a NPW of -$170.32 per acre (Table 34). This financially optimal rotation would produce an estimated 3,965.81 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 19.55 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 42 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $1,225.35 (Table 38), with a NPW of $1,095.82 per acre (Table 34). This financially optimal rotation would produce an estimated 3,687.76 cubic feet of pulpwood and 6.57 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 26.06 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 57 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $499.15 (Table 38), with a NPW of $493.26 per acre (Table 34). This financially optimal rotation would produce an estimated 4,001.56 cubic feet of pulpwood and 4.70 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 25.74 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $220.37 (Table 38), with a NPW of $220.06 per acre (Table 34). This financially optimal rotation would

produce an estimated 4,255.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 23.25 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $56.30 (Table 38), with a NPW of $56.29 per acre (Table 34). This financially optimal rotation would produce an estimated 4,255.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 23.25 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$48.77 (Table 38), with a NPW of -$48.77 per acre (Table 34). This financially optimal rotation would produce an estimated 4,255.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 23.25 net tons of carbon per acre during one rotation (Table 26).

White ash, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$120.06 (Table 38),

with a NPW of -$120.06 per acre (Table 34). This financially optimal rotation would produce an estimated 4,255.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 42), and sequester 23.25 net tons of carbon per acre during one rotation (Table 26).

Species White ash Region Northeast

Site indices 60, 70 and 80 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 6.70, 7.80, and 9.70 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 20 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183628319 and 0.553097345, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Perala and Alban (1994) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$Y = 0.01424D^{1.512}H^{1.1518}*1000$$

where:

Y = component dry-weight (kg.)

D = diameter at breast height (cm.)

H = height (cm.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisors 2005). The price of sawtimber was assumed to be $114/mbf (International 1/4) (WVU Division of Forestry, http://ahc.caf.wvu.edu/., University of Maryland, http://www.naturalresources.umd.edu/Stumpage_Prices.cfm., Universities of Connecticut and Massachusetts, http://forest.fnr.umass.edu/snestumpage.htm., University of Vermont Extension, http://stumpage.uvm.edu/stumpage.php., Maine Department of Conservation, http://www.state.me.us/doc/mfs/pubs.htm. February 3, 2006) and pulpwood price was assumed to be $8.66/cord (WVU Division of Forestry, http://ahc.caf.wvu.edu/., University of Maryland, http://www.naturalresources.umd.edu/Stumpage_Prices.cfm., Universities of Connecticut and Massachusetts, http://forest.fnr.umass.edu/snestumpage.htm., University of Vermont Extension, http://stumpage.uvm.edu/stumpage.php., Maine Department of Conservation, http://www.state.me.us/doc/mfs/pubs.htm. February 3, 2006). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of white ash plantations in the Northeast.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$218.00	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]The seedling cost was estimated based on the seedling prices from Maryland DNR Forest Service (http://www.dnr.state.md.us/forests/nursery/deciduous.html. Feb.8,2006), Croshaw Nursery (http://www.croshawnursery.com/PriceList.html. Feb.8, 2006) and New Hampshire State Forest Nursery (http://www.nh.gov/dred/nhnursery/seedlings.htm. Feb.8,2006).

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Table 45. Total tons of carbon sequestered per acre for white ash plantations in the Northeast United States by site index and real alternative rates of return. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	17.33	17.33	17.33	17.02	17.02	17.02
70	23.33	22.45	21.55	21.55	21.55	21.55
80	25.53	25.53	25.53	25.53	24.25	24.25

[1]Base age 50.

Table 46. Total tons of carbon sequestered per acre for white ash plantations in the Northeast United States by site index and real alternative rates of return. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	17.33	18.38	18.38	18.38	18.38	18.38
70	23.33	22.45	22.45	21.64	21.64	21.64
80	25.53	25.53	25.53	25.53	25.53	25.53

[1]Base age 50.

Table 47. Total tons of carbon sequestered per acre for white ash plantations in the Northeast United States by site index and real alternative rates of return. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	18.23	18.04	18.04	18.04	18.04	18.04
70	23.33	21.8	21.03	19.01	19.01	19.01
80	26.01	24.69	24.57	24.25	24.25	24.25

[1]Base age 50.

Table 48. Total tons of carbon sequestered per acre for white ash plantations in the Northeast United States by site index and real alternative rates of return. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	18.25	18.04	18.04	18.04	18.04	18.04
70	23.33	21.03	19.01	19.01	19.01	19.01
80	26.01	24.93	24.31	24.25	24.25	24.25

[1]Base age 50.

Table 49. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<42-49-**89**[2] >[3] (30%)[4]	<42-49-**89>** (30%)	<42-49-**89>** (30%)	<42-48-**87>** (30%)	<42-48-**87>** (30%)	<42-48-**87>** (30%)
70	<35-44-**89>** (30%)	<35-44-**77>** (30%)	<30-38-**74>** (30%)	<30-38-**74>** (30%)	<30-38-**74>** (30%)	<30-38-**74>** (30%)
80	<41-52-**82>** (20%)	<41-52-**82>** (20%)	<41-52-**82>** (20%)	<41-52-**82>** (20%)	<40-51-**78**> (20%)	<40-51-**78**> (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3] Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4.] Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 50. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<42-49-**89**[2] >[3] (30%)[4]	<67-72-**90**> (20%)	<67-72-**90**> (20%)	<67-72-**90**> (20%)	<67-72-**90**> (20%)	<67-72-**90**> (20%)
70	<35-44-**89>** (30%)	<35-44-**77>** (30%)	<35-44-**77>** (30%)	<30-42-**75>** (30%)	<30-42-**75>** (30%)	<30-42-**75>** (30%)
80	41-52-**82** (20%)	<41-52-**82>** (20%)	<41-52-**82>** (20%)	<41-52-**82>** (20%)	<41-52-**82>** (20%)	<41-52-**82>** (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3] Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4.] Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 51. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	73-78-**89**[2] (20%)[3]	75-85-**90** (20%)	<75-85-**90**> (20%)	<75-85-**90**> (20%)	<75-85-**90**> (20%)	<75-85-**90**> (20%)
70	35-44-**89** (30%)	35-**89** (30%)	73-78-**90** (30%)	**<90>**	**<90>**	**<90>**
80	41-84-**89** (20%)	69-81-**86** (20%)	75-85-**90** (20%)	75-85-**90** (20%)	75-85-**90** (20%)	75-85-**90** (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 52. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	75-81-**90**[2] (20%)[3]	75-85-**90** (20%)	75-85-**90** (20%)	<75-85-**90**> (20%)	<75-85-**90**> (20%)	<75-85-**90**> (20%)
70	35-44-**89** (30%)	73-78-**90** (30%)	**90**	**90**	**<90>**	**<90>**
80	41-84-**89** (20%)	69-82-**87** (20%)	74-84-**89** (20%)	75-85-**90** (20%)	75-85-**90** (20%)	75-85-**90** (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 53. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$388.89	-$460.81	-$467.31	-$466.51	-$465.25	-$464.23
70	-$306.45	-$442.08	-$461.36	-$463.93	-$464.01	-$463.59
80	-$191.25	-$326.23	-$343.12	-$344.08	-$343.07	-$342.11

[1]Base age 50.

Table 54. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$225.12	-$321.67	-$353.79	-$375.48	-$391.04	-$402.64
70	-$83.92	-$273.11	-$329.02	-$357.33	-$376.11	-$389.90
80	$83.56	-$105.42	-$167.20	-$201.13	-$224.64	-$242.33

[1]Base age 50.

Table 55. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$271.83	$91.13	-$38.35	-$126.87	-$189.67	-$235.97
70	$516.91	$186.22	$35.48	-$64.36	-$135.99	-$189.44
80	$850.55	$494.61	$312.26	$187.01	$96.13	$27.52

[1]Base age 50.

Table 56. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$533.39	$290.03	$113.55	-$7.17	-$92.71	-$155.72
70	$806.20	$412.01	$213.28	$77.32	-$20.17	-$92.84
80	$1,219.20	$789.58	$544.19	$374.07	$250.60	$157.45

[1]Base age 50.

Table 57. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$436.15	-$466.59	-$468.00	-$466.62	-$465.27	-$464.23
70	-$343.69	-$452.14	-$463.40	-$464.30	-$464.07	-$463.61
80	-$219.52	-$332.02	-$343.97	-$344.21	-$343.10	-$342.12

[1]Base age 50.

Table 58. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$252.48	-$325.51	-$354.28	-$375.55	-$391.05	-$402.64
70	-$94.12	-$279.32	-$330.19	-$357.59	-$376.16	-$389.91
80	$95.92	-$107.29	-$167.62	-$201.21	-$224.66	-$242.33

[1]Base age 50.

Table 59. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$304.86	$92.22	-$38.41	-$126.90	-$189.67	-$235.97
70	$579.72	$188.55	$35.53	-$64.37	-$135.99	-$189.44
80	$953.92	$501.80	$312.80	$187.05	$96.13	$27.52

[1]Base age 50.

Table 60. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$596.44	$293.49	$113.71	-$7.17	-$92.71	-$155.72
70	$904.17	$416.93	$213.57	$77.34	-$20.17	-$92.84
80	$1,367.36	$800.51	$545.00	$374.13	$250.61	$157.45

[1]Base age 50.

Table 61. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the Northeast United States. (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.50%	<42-49-**89**[3] > (30%)[4]	556.65	0	569.67	0	1,928.54	5.33	3,054.86	5.33
	5.00%	<42-49-**89**> (30%)	556.65	0	569.67	0	1,928.54	5.33	3,054.86	5.33
	7.50%	<42-49-**89**> (30%)	556.65	0	569.67	0	1,928.54	5.33	3,054.86	5.33
	10.00%	<42-48-**87**> (30%)	556.65	0	558.49	0	2,003.84	4.26	3,118.98	4.26
	12.50%	<42-48-**87**> (30%)	556.65	0	558.49	0	2,003.84	4.26	3,118.98	4.26
	15.00%	<42-48-**87**> (30%)	556.65	0	558.49	0	2,003.84	4.26	3,118.98	4.26
70	2.50%	<35-44-**89**> (30%)	676.71	0	706.27	0	1,921.83	10.70	3,304.81	10.70
	5.00%	<35-44-**77**> (30%)	676.71	0	706.27	0	2,125.99	7.33	3,508.97	7.33
	7.50%	<30-38-**74**> (30%)	633.81	0	563.75	0	2,427.18	4.36	3,624.74	4.36
	10.00%	<30-38-**74**> (30%)	633.81	0	563.75	0	2,427.18	4.36	3,624.74	4.36
	12.50%	<30-38-**74**> (30%)	633.81	0	563.75	0	2,427.18	4.36	3,624.74	4.36
	15.00%	<30-38-**74**> (30%)	633.81	0	563.75	0	2,427.18	4.36	3,624.74	4.36
80	2.50%	<41-52-**82**> (20%)	597.14	0	618.54	0	2,338.48	8.85	3,554.16	8.85
	5.00%	<41-52-**82**> (20%)	597.14	0	618.54	0	2,338.48	8.85	3,554.16	8.85
	7.50%	<41-52-**82**> (20%)	597.14	0	618.54	0	2,338.48	8.85	3,554.16	8.85
	10.00%	<41-52-**82**> (20%)	597.14	0	618.54	0	2,338.48	8.85	3,554.16	8.85
	12.50%	<40-51-**78**> (20%)	591.10	0	572.67	0	2,566.63	4.60	3,730.40	4.60
	15.00%	<40-51-**78**> (20%)	591.10	0	572.67	0	2,566.63	4.60	3,730.40	4.60

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 62. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the Northeast United States. (carbon value = $10/ton)

Site Index[1]	ARR	Schedule	1st thinning Cu. Ft.	1st thinning MBF[2]	2nd thinning Cu. Ft.	2nd thinning MBF	Final Harvest Cu. Ft.	Final Harvest MBF	Total Volume Cu. Ft.	Total Volume MBF
60	2.50%	<42-49-**89**[3] > (30%)[4]	556.65	0	569.67	0	1,928.54	5.33	3,054.86	5.33
	5.00%	<67-72-**90**> (20%)	663.55	0	554.94	0	2,720.95	0	3,939.44	0
	7.50%	<67-72-**90**> (20%)	663.55	0	554.94	0	2,720.95	0	3,939.44	0
	10.00%	<67-72-**90**> (20%)	663.55	0	554.94	0	2,720.95	0	3,939.44	0
	12.50%	<67-72-**90**> (20%)	663.55	0	554.94	0	2,720.95	0	3,939.44	0
	15.00%	<67-72-**90**> (20%)	663.55	0	554.94	0	2,720.95	0	3,939.44	0
70	2.50%	<35-44-**89>** (30%)	676.71	0	706.27	0	1,921.83	10.70	3,304.81	10.70
	5.00%	<35-44-**77>** (30%)	676.71	0	706.27	0	2,125.99	7.33	3,508.97	7.33
	7.50%	<35-44-**77>** (30%)	676.71	0	706.27	0	2,125.99	7.33	3,508.97	7.33
	10.00%	<30-42-**75>** (30%)	633.81	0	713.43	0	2,413.02	4.33	3,760.26	4.33
	12.50%	<30-42-**75>** (30%)	633.81	0	713.43	0	2,413.02	4.33	3,760.26	4.33
	15.00%	<30-42-**75>** (30%)	633.81	0	713.43	0	2,413.02	4.33	3,760.26	4.33
80	2.50%	41-52-**82** (20%)	597.14	0	618.54	0	2,338.48	8.85	3,554.16	8.85
	5.00%	<41-52-**82>** (20%)	597.14	0	618.54	0	2,338.48	8.85	3,554.16	8.85
	7.50%	<41-52-**82>** (20%)	597.14	0	618.54	0	2,338.48	8.85	3,554.16	8.85
	10.00%	<41-52-**82>** (20%)	597.14	0	618.54	0	2,338.48	8.85	3,554.16	8.85
	12.50%	<41-52-**82>** (20%)	597.14	0	618.54	0	2,338.48	8.85	3,554.16	8.85
	15.00%	<41-52-**82>** (20%)	597.14	0	618.54	0	2,338.48	8.85	3,554.16	8.85

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 63. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the Northeast United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.50%	73-78-**89**[3] (20%)[4]	692.50	0	575.34	0	2617.64	0	3,885.48	0
	5.00%	75-85-**90** (20%)	703.89	0	602.25	0	2558.92	0	3,865.06	0
	7.50%	75-85-**90** (20%)	703.89	0	602.25	0	2558.92	0	3,865.06	0
	10.00%	75-85-**90** (20%)	703.89	0	602.25	0	2558.92	0	3,865.06	0
	12.50%	75-85-**90** (20%)	703.89	0	602.25	0	2558.92	0	3,865.06	0
	15.00%	75-85-**90** (20%)	703.89	0	602.25	0	2558.92	0	3,865.06	0
70	2.50%	35-44-**89** (30%)	676.71	0	706.27	0	1,921.83	10.70	3,304.81	10.70
	5.00%	35-**89** (30%)	676.71	0	-[5]	-	2,442.74	10.18	3,119.45	10.18
	7.50%	73-78-**90** (30%)	1127.08	0	834.37	0	2,037.00	3.66	3,998.45	3.66
	10.00%	**90**	-[5]	-	-	-	3,943.71	0	3,943.71	0
	12.50%	**90**	-	-	-	-	3,943.71	0	3,943.71	0
	15.00%	**90**	-	-	-	-	3,943.71	0	3,943.71	0
80	2.50%	41-84-**89** (20%)	597.14	0	658.11	1.18	2,303.41	9.13	3,558.66	10.31
	5.00%	69-81-**86** (20%)	880.05	0	761.75	0	2,458.44	4.41	4,100.24	4.41
	7.50%	75-85-**90** (20%)	882.31	0	752.91	0	2,441.83	4.39	4,077.05	4.39
	10.00%	75-85-**90** (20%)	883.39	0	752.36	0	2,427.56	4.40	4,063.31	4.40
	12.50%	75-85-**90** (20%)	883.39	0	752.36	0	2,427.56	4.40	4,063.31	4.40
	15.00%	75-85-**90** (20%)	883.39	0	752.36	0	2,427.56	4.40	4,063.31	4.40

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 64. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the Northeast United States. (carbon value = $50/ton)

			1^{st} thinning		2^{nd} thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.50%	75-81-**90**[3] (20%)[4]	703.89	0	587.26	0	2,604.96	0	3,896.11	0
	5.00%	75-85-**90** (20%)	703.89	0	602.25	0	2,558.92	0	3,865.06	0
	7.50%	75-85-**90** (20%)	703.89	0	602.25	0	2,558.92	0	3,865.06	0
	10.00%	<75-85-**90**> (20%)	703.89	0	602.25	0	2,558.92	0	3,865.06	0
	12.50%	<75-85-**90**> (20%)	703.89	0	602.25	0	2,558.92	0	3,865.06	0
	15.00%	<75-85-**90**> (20%)	703.89	0	602.25	0	2,558.92	0	3,865.06	0
70	2.50%	35-44-**89** (30%)	676.71	0	706.27	0	1,921.83	10.70	3,304.81	10.70
	5.00%	73-78-**90** (30%)	1127.08	0	834.37	0	2,037.00	3.66	3,998.45	3.66
	7.50%	**90**	-[5]	-	-	-	3,943.71	0	3,943.71	0
	10.00%	**90**	-	-	-	-	3,943.71	0	3,943.71	0
	12.50%	**<90>**	-	-	-	-	3,943.71	0	3,943.71	0
	15.00%	**<90>**	-	-	-	-	3,943.71	0	3,943.71	0
80	2.50%	41-84-**89** (20%)	597.14	0	658.11	1.18	2,303.41	9.13	3,558.66	10.31
	5.00%	69-82-**87** (20%)	880.05	0	766.28	0	2,480.61	4.46	4,126.94	4.46
	7.50%	74-84-**89** (20%)	883.16	0	752.65	0	2,429.35	4.39	4,065.16	4.39
	10.00%	75-85-**90** (20%)	883.39	0	752.36	0	2,427.56	4.40	4,063.31	4.40
	12.50%	75-85-**90** (20%)	883.39	0	752.36	0	2,427.56	4.40	4,063.31	4.40
	15.0%	75-85-**90** (20%)	883.39	0	752.36	0	2,427.56	4.40	4,063.31	4.40

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 65. Financially optimal thinning and final harvest schedules for white ash plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	60	<42-49-**89**[2] >[3] (30%)[4]	<42-49-**89**> (30%)	0%	73-78-**89** (20%)	0%	75-81-**90** (20%)	1%
	70	<35-44-**89**> (30%)	<35-44-**89**> (30%)	0%	35-44-**89** (30%)	0%	35-44-**89** (30%)	0%
	80	<41-52-**82**> (20%)	41-52-**82** (20%)	0%	41-84-**89** (20%)	9%	41-84-**89** (20%)	9%
5.00%	60	<42-49-**89**> (30%)	<67-72-**90**> (20%)	1%	75-85-**90** (20%)	1%	75-85-**90** (20%)	1%
	70	<35-44-**77**> (30%)	<35-44-**77**> (30%)	0%	35-**89** (30%)	16%	73-78-**90** (30%)	17%
	80	<41-52-**82**> (20%)	<41-52-**82**> (20%)	0%	69-81-**86** (20%)	5%	69-82-**87** (20%)	6%
7.50%	60	<42-49-**89**> (30%)	<67-72-**90**> (20%)	1%	<75-85-**90**> (20%)	1%	75-85-**90** (20%)	1%
	70	<30-38-**74**> (30%)	<35-44-**77**> (30%)	4%	73-78-**90** (30%)	22%	**90**	22%
	80	<41-52-**82**> (20%)	<41-52-**82**> (20%)	0%	75-85-**90** (20%)	10%	74-84-**89** (20%)	9%
10.00%	60	<42-48-**87**> (30%)	<67-72-**90**> (20%)	3%	<75-85-**90**> (20%)	3%	<75-85-**90**> (20%)	3%
	70	<30-38-**74**> (30%)	<30-42-**75**> (30%)	1%	**<90>**	22%	**90**	22%
	80	<41-52-**82**> (20%)	<41-52-**82**> (20%)	0%	75-85-**90** (20%)	10%	75-85-**90** (20%)	10%
12.50%	60	<42-48-**87**> (30%)	<67-72-**90**> (20%)	3%	<75-85-**90**> (20%)	3%	<75-85-**90**> (20%)	3%
	70	<30-38-**74**> (30%)	<30-42-**75**> (30%)	1%	**<90>**	22%	**<90>**	22%
	80	<40-51-**78**> (20%)	<41-52-**82**> (20%)	5%	75-85-**90** (20%)	15%	75-85-**90** (20%)	15%
15.00%	60	<42-48-**87**> (30%)	<67-72-**90**> (20%)	3%	<75-85-**90**> (20%)	3%	<75-85-**90**> (20%)	3%
	70	<30-38-**74**> (30%)	<30-42-**75**> (30%)	1%	**<90>**	22%	**<90>**	22%
	80	<40-51-**78**> (20%)	<41-52-**82**> (20%)	5%	75-85-**90** (20%)	15%	75-85-**90** (20%)	15%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

[4]Number in parentheses indicates the percentage of basal area removed during thinning

Table 66. The soil expectation value ($/acre) of the financially optimal rotations for white ash plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	60	-436.15	-252.48		304.86		596.44	
	70	-343.69	-94.12		579.72		904.17	
	80	-219.52	95.92		953.92		1,367.36	
5.00%	60	-466.59	-325.51		92.22		293.49	
	70	-452.14	-279.32		188.55		416.93	
	80	-332.02	-107.29		501.80		800.51	
7.50%	60	-468.00	-354.28		-38.41		113.71	
	70	-463.40	-330.19		35.53		213.57	
	80	-343.97	-167.62		312.80		545.00	
10.00%	60	-466.62	-375.55		-126.90		-7.17	
	70	-464.30	-357.59		-64.37		77.34	
	80	-344.21	-201.21		187.05		374.13	
12.50%	60	-465.27	-391.05		-189.67		-92.71	
	70	-464.07	-376.16		-135.99		-20.17	
	80	-343.10	-224.66		96.13		250.61	
15.00%	60	-464.23	-402.64		-235.97		-155.72	
	70	-463.61	-389.91		-189.44		-92.84	
	80	-342.12	-242.33		27.52		157.45	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

Northeast- White ash - Timber Only Rotations (C = $0/ton)

White ash, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 49). This optimal management regime will generate the maximum SEV of -$436.15 (Table 57), with a NPW of -$388.89 per acre (Table 53). This means that -$436.15 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$388.89 per acre for managing one rotation, or -$436.15 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,054.86 cubic feet of pulpwood and 5.33 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 17.33 net tons of carbon per acre during one rotation (Table 45). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 49). This optimal management regime will generate the maximum SEV of -$466.59 (Table 57), with a NPW of -$460.81 per acre (Table 53). This financially optimal

rotation would produce an estimated 3,054.86 cubic feet of pulpwood and 5.33 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 17.33 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 49). This optimal management regime will generate the maximum SEV of -$468.00 (Table 57), with a NPW of -$467.31 per acre (Table 53). This financially optimal rotation would produce an estimated 3,054.86 cubic feet of pulpwood and 5.33 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 17.33 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 49). This optimal management regime will generate the maximum SEV of -$466.62 (Table 57), with a NPW of -$466.51 per acre (Table 53). This financially optimal rotation would produce an estimated 3,118.98 cubic feet of pulpwood and 4.26 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 17.02 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 49). This optimal management regime will generate the maximum SEV of -$465.27 (Table 57), with a NPW of -$465.25 per acre (Table 53). This financially optimal rotation would produce an estimated 3,118.98 cubic feet of pulpwood and 4.26 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 17.02 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 49). This optimal management regime will generate the maximum SEV of -$464.23 (Table 57), with a NPW of -$464.23 per acre (Table 53). This financially optimal rotation would produce an estimated 3,118.98 cubic feet of pulpwood and 4.26 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 17.02 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 49). This optimal management regime will generate the maximum SEV of -$343.69 (Table 57), with a NPW of -$306.45 per acre (Table 53). This financially optimal

rotation would produce an estimated 3,304.81 cubic feet of pulpwood and 10.70 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 23.33 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 49). This optimal management regime will generate the maximum SEV of -$452.14 (Table 57), with a NPW of -$442.08 per acre (Table 53). This financially optimal rotation would produce an estimated 3,508.97 cubic feet of pulpwood and 7.33 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 22.45 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 38 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 49). This optimal management regime will generate the maximum SEV of -$463.40 (Table 57), with a NPW of -$461.36 per acre (Table 53). This financially optimal rotation would produce an estimated 3,624.74 cubic feet of pulpwood and 4.36 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 21.55 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 38 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 49). This optimal management regime will generate the maximum SEV of -$464.30 (Table 57), with a NPW of -$463.93 per acre (Table 53). This financially optimal rotation would produce an estimated 3,624.74 cubic feet of pulpwood and 4.36 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 21.55 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 38 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 49). This optimal management regime will generate the maximum SEV of -$464.07 (Table 57), with a NPW of -$464.01 per acre (Table 53). This financially optimal rotation would produce an estimated 3,624.74 cubic feet of pulpwood and 4.36 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 21.55 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 38 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 49). This optimal management regime will generate the maximum SEV of -$463.61 (Table 57), with a NPW of -$463.59 per acre (Table 53). This financially optimal

rotation would produce an estimated 3,624.74 cubic feet of pulpwood and 4.36 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 21.55 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 52 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 49). This optimal management regime will generate the maximum SEV of -$219.52 (Table 57), with a NPW of -$191.25 per acre (Table 53). This financially optimal rotation would produce an estimated 3,554.16 cubic feet of pulpwood and 8.85 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 25.53 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 52 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 49). This optimal management regime will generate the maximum SEV of -$332.02 (Table 57), with a NPW of -$326.23 per acre (Table 53). This financially optimal rotation would produce an estimated 3,554.16 cubic feet of pulpwood and 8.85 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 25.53 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 52 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 49). This optimal management regime will generate the maximum SEV of -$343.97 (Table 57), with a NPW of -$343.12 per acre (Table 53). This financially optimal rotation would produce an estimated 3,554.16 cubic feet of pulpwood and 8.85 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 25.53 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 52 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 49). This optimal management regime will generate the maximum SEV of -$344.21 (Table 57), with a NPW of -$344.08 per acre (Table 53). This financially optimal rotation would produce an estimated 3,554.16 cubic feet of pulpwood and 8.85 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 25.53 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 78 (Table 49). This optimal management regime will generate the maximum SEV of -$343.10 (Table 57), with a NPW of -$343.07 per acre (Table 53). This financially optimal

rotation would produce an estimated 3,730.40 cubic feet of pulpwood and 4.60 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 24.25 net tons of carbon per acre during one rotation (Table 45).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 51 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 78 (Table 49). This optimal management regime will generate the maximum SEV of -$342.12 (Table 57), with a NPW of -$342.11 per acre (Table 53). This financially optimal rotation would produce an estimated 3,730.40 cubic feet of pulpwood and 4.60 MBF of sawlogs per acre from the thinning and final harvest (Table 61), and sequester 24.25 net tons of carbon per acre during one rotation (Table 45).

<u>Northeast- White ash - Timber Only Rotations (C = $10/ton)</u>

White ash, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 50). This optimal management regime will generate the maximum SEV of -$252.48 (Table 58), with a NPW of -$225.12 per acre (Table 54). This means that -$252.48 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on

every dollar invested plus -$225.12 per acre for managing one rotation, or -$252.48 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,054.86 cubic feet of pulpwood and 5.33 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 17.33 net tons of carbon per acre during one rotation (Table 46). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 67 and 72 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 50). This optimal management regime will generate the maximum SEV of -$325.51 (Table 58), with a NPW of -$321.67 per acre (Table 54). This financially optimal rotation would produce an estimated 3,939.44 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 18.38 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 67 and 72 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 50). This optimal management regime will generate the maximum SEV of -$354.28 (Table 58), with a NPW of -$353.79 per acre (Table 54). This financially optimal rotation would produce an estimated 3,939.44 cubic feet of pulpwood and 0.00 MBF of

sawlogs per acre from the thinning and final harvest (Table 62), and sequester 18.38 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 67 and 72 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 50). This optimal management regime will generate the maximum SEV of -$375.55 (Table 58), with a NPW of -$375.48 per acre (Table 54). This financially optimal rotation would produce an estimated 3,939.44 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 18.38 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 67 and 72 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 50). This optimal management regime will generate the maximum SEV of -$391.05 (Table 58), with a NPW of -$391.04 per acre (Table 54). This financially optimal rotation would produce an estimated 3,939.44 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 18.38 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 67 and 72 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 50). This optimal management regime will generate the maximum SEV of -$402.64 (Table 58), with a NPW of -$402.64 per acre (Table 54). This financially optimal rotation would produce an estimated 3,939.44 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 18.38 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 50). This optimal management regime will generate the maximum SEV of -$94.12 (Table 58), with a NPW of -$83.92 per acre (Table 54). This financially optimal rotation would produce an estimated 3,304.81 cubic feet of pulpwood and 10.70 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 23.33 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 50). This optimal management regime will generate the maximum SEV of -$279.32 (Table 58), with a NPW of -$273.11 per acre (Table 54). This financially optimal rotation would produce an estimated 3,508.97 cubic feet of pulpwood and 7.33 MBF of

sawlogs per acre from the thinning and final harvest (Table 62), and sequester 22.45 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 50). This optimal management regime will generate the maximum SEV of -$330.19 (Table 58), with a NPW of -$329.02 per acre (Table 54). This financially optimal rotation would produce an estimated 3,508.97 cubic feet of pulpwood and 7.33 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 22.45 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 42 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 50). This optimal management regime will generate the maximum SEV of -$357.59 (Table 58), with a NPW of -$357.33 per acre (Table 54). This financially optimal rotation would produce an estimated 3,760.26 cubic feet of pulpwood and 4.33 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 21.64 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 42 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 50). This optimal management regime will generate the maximum SEV of -$376.16 (Table 58), with a NPW of -$376.11 per acre (Table 54). This financially optimal rotation would produce an estimated 3,760.26 cubic feet of pulpwood and 4.33 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 21.64 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 42 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 50). This optimal management regime will generate the maximum SEV of -$389.91 (Table 58), with a NPW of -$389.90 per acre (Table 54). This financially optimal rotation would produce an estimated 3,760.26 cubic feet of pulpwood and 4.33 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 21.64 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 52 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 50). This optimal management regime will generate the maximum SEV of $95.92 (Table 58), with a NPW of $83.56 per acre (Table 54). This financially optimal rotation would produce an estimated 3,554.16 cubic feet of pulpwood and 8.85 MBF of sawlogs per acre

from the thinning and final harvest (Table 62), and sequester 25.53 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 52 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 50). This optimal management regime will generate the maximum SEV of -$107.29 (Table 58), with a NPW of -$105.42 per acre (Table 54). This financially optimal rotation would produce an estimated 3,554.16 cubic feet of pulpwood and 8.85 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 25.53 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 52 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 50). This optimal management regime will generate the maximum SEV of -$167.62 (Table 58), with a NPW of -$167.20 per acre (Table 54). This financially optimal rotation would produce an estimated 3,554.16 cubic feet of pulpwood and 8.85 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 25.53 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 52 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 50). This optimal management regime will generate the maximum SEV of -$201.21 (Table 58), with a NPW of -$201.13 per acre (Table 54). This financially optimal rotation would produce an estimated 3,554.16 cubic feet of pulpwood and 8.85 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 25.53 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 52 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 50). This optimal management regime will generate the maximum SEV of -$224.66 (Table 58), with a NPW of -$224.64 per acre (Table 54). This financially optimal rotation would produce an estimated 3,554.16 cubic feet of pulpwood and 8.85 MBF of sawlogs per acre from the thinning and final harvest (Table 62), and sequester 25.53 net tons of carbon per acre during one rotation (Table 46).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 52 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 50). This optimal management regime will generate the maximum SEV of -$242.33 (Table 58), with a NPW of -$242.33 per acre (Table 54). This financially optimal rotation would produce an estimated 3,554.16 cubic feet of pulpwood and 8.85 MBF of

sawlogs per acre from the thinning and final harvest (Table 62), and sequester 25.53 net tons of carbon per acre during one rotation (Table 46).

<u>Northeast-White ash - Timber Only Rotations (C = $37/ton)</u>

White ash, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 73 and 78 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 51). This optimal management regime will generate the maximum SEV of $304.86 (Table 59), with a NPW of $271.83 per acre (Table 55). This means that $304.86 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $271.83 per acre for managing one rotation, or $304.86 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,885.48 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 18.23 net tons of carbon per acre during one rotation (Table 47). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of $92.22 (Table 59), with a NPW of $91.13 per acre (Table 55). This financially optimal rotation would produce an estimated 3,865.06 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 18.04 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of -$38.41 (Table 59), with a NPW of -$38.35 per acre (Table 55). This financially optimal rotation would produce an estimated 3,865.06 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 18.04 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of -$126.90 (Table 59), with a NPW of -$126.87 per acre (Table 55). This financially optimal rotation would produce an estimated 3,865.06 cubic feet of pulpwood and 0.00 MBF of

sawlogs per acre from the thinning and final harvest (Table 63), and sequester 18.04 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of -$189.67 (Table 59), with a NPW of -$189.67 per acre (Table 55). This financially optimal rotation would produce an estimated 3,865.06 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 18.04 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of -$235.97 (Table 59), with a NPW of -$235.97 per acre (Table 55). This financially optimal rotation would produce an estimated 3,865.06 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 18.04 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 44 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 51). This optimal management regime will generate the maximum SEV of $579.72 (Table 59), with a NPW of $516.91 per acre (Table 55). This financially optimal rotation would produce an estimated 3,304.81 cubic feet of pulpwood and 10.70 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 23.33 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 51). This optimal management regime will generate the maximum SEV of $188.55 (Table 59), with a NPW of $186.22 per acre (Table 55). This financially optimal rotation would produce an estimated 3,119.45 cubic feet of pulpwood and 10.18 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 21.80 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 73 and 78 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of $35.53 (Table 59), with a NPW of $35.48 per acre (Table 55). This financially optimal rotation would produce an estimated 3,998.45 cubic feet of pulpwood and 3.66 MBF of sawlogs per acre

from the thinning and final harvest (Table 63), and sequester 21.03 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of -$64.37 (Table 59), with a NPW of -$64.36 per acre (Table 55). This financially optimal rotation would produce an estimated 3,943.71 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 19.01 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of -$135.99 (Table 59), with a NPW of -$135.99 per acre (Table 55). This financially optimal rotation would produce an estimated 3,943.71 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 19.01 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of -$189.44 (Table 59), with a NPW of -$189.44 per acre (Table 55). This financially optimal rotation would

produce an estimated 3,943.71 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 19.01 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 84 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 51). This optimal management regime will generate the maximum SEV of $953.92 (Table 59), with a NPW of $850.55 per acre (Table 55). This financially optimal rotation would produce an estimated 3,558.66 cubic feet of pulpwood and 10.31 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 26.01 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 69 and 81 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 86 (Table 51). This optimal management regime will generate the maximum SEV of $501.80 (Table 59), with a NPW of $494.61 per acre (Table 55). This financially optimal rotation would produce an estimated 4,100.24 cubic feet of pulpwood and 4.41 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 24.69 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of $312.80 (Table 59), with a NPW of $312.26 per acre (Table 55). This financially optimal rotation would produce an estimated 4,077.05 cubic feet of pulpwood and 4.39 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 24.57 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of $187.05 (Table 59), with a NPW of $187.01 per acre (Table 55). This financially optimal rotation would produce an estimated 4,077.05 cubic feet of pulpwood and 4.39 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 24.57 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of $96.13 (Table 59), with a NPW of $96.13 per acre (Table 55). This financially optimal rotation would

produce an estimated 4,077.05 cubic feet of pulpwood and 4.39 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 24.57 net tons of carbon per acre during one rotation (Table 47).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 51). This optimal management regime will generate the maximum SEV of $27.52 (Table 59), with a NPW of $27.52 per acre (Table 55). This financially optimal rotation would produce an estimated 4,077.05 cubic feet of pulpwood and 4.39 MBF of sawlogs per acre from the thinning and final harvest (Table 63), and sequester 24.57 net tons of carbon per acre during one rotation (Table 47).

Northeast- White ash - Timber Only Rotations (C = $50/ton)

White ash, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 71 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $596.44 (Table 60), with a NPW of $533.39 per acre (Table 56). This means that $596.44 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on

every dollar invested plus $533.39 per acre for managing one rotation, or $596.44 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 3,896.11 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 18.25 net tons of carbon per acre during one rotation (Table 48). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age90 (Table 52). This optimal management regime will generate the maximum SEV of $293.49 (Table 60), with a NPW of $290.03 per acre (Table 56). This financially optimal rotation would produce an estimated 3,865.06 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 18.04 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $113.71 (Table 60), with a NPW of $113.55 per acre (Table 56). This financially optimal rotation would produce an estimated 3,865.06 cubic feet of pulpwood and 0.00 MBF of sawlogs

per acre from the thinning and final harvest (Table 64), and sequester 18.04 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of -$7.17 (Table 60), with a NPW of -$7.17 per acre (Table 56). This financially optimal rotation would produce an estimated 3,865.06 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 18.04 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of -$92.71 (Table 60), with a NPW of -$92.71 per acre (Table 56). This financially optimal rotation would produce an estimated 3,865.06 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 18.04 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of -$155.72 (Table 60), with a NPW of -$155.72 per acre (Table 56). This financially optimal rotation would produce an estimated 3,865.06 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 18.04 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 52). This optimal management regime will generate the maximum SEV of $904.17 (Table 60), with a NPW of $806.20 per acre (Table 56). This financially optimal rotation would produce an estimated 3,304.81 cubic feet of pulpwood and 10.70 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 23.33 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 73 and 78 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $416.93 (Table 60), with a NPW of $412.01 per acre (Table 56). This financially optimal rotation would produce an estimated 3,998.45 cubic feet of pulpwood and 3.66 MBF of sawlogs

per acre from the thinning and final harvest (Table 64), and sequester 21.03 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $213.57 (Table 60), with a NPW of $213.28 per acre (Table 56). This financially optimal rotation would produce an estimated 3,943.71 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 19.01 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $77.34 (Table 60), with a NPW of $77.32 per acre (Table 56). This financially optimal rotation would produce an estimated 3,943.71 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 19.01 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of -$20.17 (Table 60), with a NPW of -$20.17 per acre (Table 56). This financially optimal rotation would produce

an estimated 3,943.71 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 19.01 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of -$92.84 (Table 60), with a NPW of -$92.84 per acre (Table 56). This financially optimal rotation would produce an estimated 3,943.71 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 19.01 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 84 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 52). This optimal management regime will generate the maximum SEV of $1,367.36 (Table 60), with a NPW of $1,219.20 per acre (Table 56). This financially optimal rotation would produce an estimated 3,558.66 cubic feet of pulpwood and 10.31 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 26.01 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 69 and 82 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 52). This optimal management regime will generate the maximum SEV of $800.51 (Table 60), with a NPW of $789.58 per acre (Table 56). This financially optimal rotation would produce an estimated 4,126.94 cubic feet of pulpwood and 4.46 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 24.93 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 74 and 84 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 52). This optimal management regime will generate the maximum SEV of $545.00 (Table 60), with a NPW of $544.19 per acre (Table 56). This financially optimal rotation would produce an estimated 4,065.16 cubic feet of pulpwood and 4.39 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 24.31 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $374.13 (Table 60), with a NPW of $374.07 per acre (Table 56). This financially optimal rotation would produce an estimated 4,063.31 cubic feet of pulpwood and 4.40 MBF of sawlogs

per acre from the thinning and final harvest (Table 64), and sequester 24.25 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $250.61 (Table 60), with a NPW of -$250.60 per acre (Table 56). This financially optimal rotation would produce an estimated 4,063.31 cubic feet of pulpwood and 4.40 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 24.25 net tons of carbon per acre during one rotation (Table 48).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 52). This optimal management regime will generate the maximum SEV of $157.45 (Table 60), with a NPW of $157.45 per acre (Table 56). This financially optimal rotation would produce an estimated 4,063.31 cubic feet of pulpwood and 4.40 MBF of sawlogs per acre from the thinning and final harvest (Table 64), and sequester 24.25 net tons of carbon per acre during one rotation (Table 48).

Species White ash Region South

Site indices 70, 80 and 90 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 9-in. inside bark top diameter for trees with a minimum of 12 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 11-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 20 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a “thinning and final harvest” regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 25, 30 and 35% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.245225694 and 0.434027778, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Clark and Schroeder (1986) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Yp = 0.15030(D^2H)^{0.93298}$$

$$Ys = 0.15789(D^2)^{0.92271}(H)^{0.93298}$$

where:

Yp = dry-weight (lbs.) of stemwood and bark of trees < 11.0 in. d.b.h

Ys = dry-weight (lbs.) of stemwood and bark of trees ≥ 11.0 in d.b.h

D = diameter at breast height (in.)

H = total height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 1.6% and 1.24% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $220/mbf (Scribner) (Timber Mart South, Inc. 2000-2005) and pulpwood price was assumed to be $16.44/cord (Timber Mart South, Inc. 2000-2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of white ash plantations in the South.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$60.00	Only once	Year 0	
Seedlings[b] (436 seedlings/ac)	$152.60	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).

[b]Data from Hans M. Williams, personal communication, Stephen F. Austin State University, December 19, 2006.

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Table 67. Total tons of carbon sequestered per acre for white ash plantations in the southern United States by site index and real alternative rates of return. (carbon value = $00/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	33.94	33.15	27.48	27.48	27.48	27.00
80	36.07	36.07	34.53	34.53	30.00	28.77
90	41.04	35.32	35.32	35.32	24.53	21.67

[1]Base age 50.

Table 68. Total tons of carbon sequestered per acre for white ash plantations in the southern United States by site index and real alternative rates of return. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	34.13	33.94	33.49	32.15	28.49	28.01
80	36.07	36.07	36.07	36.07	34.53	34.53
90	42.81	41.04	35.32	35.32	35.32	35.32

[1]Base age 50.

Table 69. Total tons of carbon sequestered per acre for white ash plantations in the southern United States by site index and real alternative rates of return. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	33.95	33.95	33.95	33.95	33.95	33.95
80	40.39	40.39	40.39	40.39	40.39	40.39
90	45.71	45.71	45.71	37.02	37.02	37.02

[1]Base age 50.

Table 70. Total tons of carbon sequestered per acre for white ash plantations in the southern United States by site index and real alternative rates of return. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	33.95	33.95	33.95	33.95	33.95	33.95
80	40.39	40.39	40.39	40.39	40.39	40.39
90	45.71	45.71	45.71	46.88	37.02	37.02

[1]Base age 50.

Table 71. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	<42-53-**60**[3]>[4] (25%)	<40-53-**60>** (30%)	<34-42-**59>** (35%)	<34-42-**59>** (35%)	<34-42-**59>** (35%)	<34-42-**58>** (35%)
80	<33-48-**60**> (35%)	<33-48-**60**> (35%)	<33-42-**60**> (35%)	<33-42-**60**> (35%)	<30-37-**56**> (35%)	<30-37-**54**> (35%)
90	33-40-**60** (35%)	<31-**60**> (30%)	<31-**60**> (30%)	<31-**60**> (30%)	<29-**43>** (30%)	<29-**39>** (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 72. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	55-**60**[3](25%)	<42-53-**60**>[4] (25%)	<40-55-**60**> (30%)	<40-48-**60**> (30%)	<35-43-**60**> (35%)	<34-42-**60**> (35%)
80	33-48-**60 (35%)**	<33-48-**60**> (35%)	<33-48-**60**> (35%)	<33-48-**60**> (35%)	<33-42-**60**> (35%)	<33-42-**60**> (35%)
90	29-53-**60** (35%)	<33-40-**60**> (35%)	<31-**60**> (30%)	<31-**60**> (30%)	<31-**60**> (30%)	<31-**60**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 73. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	**60**[3]	**60**	<**60**>[4]	<**60**>	<**60**>	<**60**>
90	**60**	**60**	<**60**>	<**60**>	<**60**>	<**60**>
90	37-52-**60** (25%)	37-52-**60** (25%)	37-52-**60** (25%)	<53-**60>** (30%)	<53-**60**> (30%)	<53-**60**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 74. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white ash plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	**60**[3]	**60**	<**60**>[4]	<**60**>	<**60**>	<**60**>
80	**60**	**60**	**60**	<**60**>	<**60**>	<**60**>
90	37-52-**60** (25%)	37-52-**60** (25%)	37-52-**60** (25%)	**60**	<53-**60>** (30%)	<53-**60>** (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 75. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$177.88	-$345.78	-$383.64	-$394.15	-$397.03	-$397.61
80	-$81.78	-$314.91	-$374.64	-$391.21	-$395.29	-$396.65
90	$279.66	-$215.82	-$311.31	-$335.35	-$339.36	-$341.27

[1]Base age 50.

Table 76. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$20.34	-$230.53	-$314.73	-$384.24	-$364.06	-$372.72
90	$137.60	-$178.58	-$285.56	-$328.88	-$349.69	-$361.31
90	$543.28	-$57.74	-$211.59	-$263.51	-$286.84	-$299.47

[1]Base age 50.

Table 77. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$568.44	$88.00	-$117.59	-$217.49	-$271.74	-$304.07
80	$792.44	$219.90	-$29.26	-$152.79	-$221.30	-$262.93
90	$1263.83	$412.65	$78.60	-$66.52	-$137.46	-$180.96

[1]Base age 50.

Table 78. Net present worth of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$833.23	$243.75	-$21.26	-$153.81	-$226.92	-$270.81
80	$1118.73	$417.93	$97.12	-$66.63	-$158.81	-$215.23
90	$1634.97	$645.66	$233.25	$32.37	-$64.86	-$123.54

[1]Base age 50.

Table 79. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	-$228.56	-$364.36	-$388.71	-$395.45	-$397.37	-$397.71
80	-$105.08	-$331.83	-$379.24	-$392.39	-$395.77	-$396.83
90	$359.34	-$227.42	-$315.13	-$336.36	-$341.28	-$342.55

[1]Base age 50.

Table 80. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$26.13	-$242.91	-$318.60	-$349.29	-$364.34	-$372.79
80	$176.80	-$188.17	-$289.07	-$329.86	-$349.95	-$361.38
90	$698.08	-$60.85	-$214.19	-$264.30	-$287.06	-$299.53

[1]Base age 50.

Table 81. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$730.40	$92.73	-$119.03	-$218.14	-$271.95	-$304.13
80	$1018.23	$231.72	-$29.62	$153.25	-$221.46	-$262.98
90	$1623.92	$434.82	$79.56	-$66.72	-$137.57	-$180.99

[1]Base age 50.

Table 82. Soil expectation value of the financially optimal thinning and final harvest schedules for white ash plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
70	$1070.63	$256.84	-$21.52	-$154.27	-$277.09	-$270.87
80	$1437.47	$440.39	$98.31	-$66.83	-$158.93	-$215.28
90	$2100.80	$680.34	$236.12	$32.47	-$64.91	-$123.57

[1]Base age 50.

Table 83. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	42-53-**60**[3] (25%)[4]	576.17	0	746.32	0	2993.55	0	4316.04	0
	5.00%	40-53-**60** (30%)	638.38	0	2082.31	0	2692.26	0	5412.95	0
	7.50%	34-42-**59** (35%)	581.42	0	575.58	0	2305.97	0	3462.97	0
	10.00%	34-42-**59** (35%)	581.42	0	575.58	0	2305.97	0	3462.97	0
	12.50%	34-42-**59** (35%)	581.42	0	575.58	0	2305.97	0	3462.97	0
	15.00%	34-42-**59** (35%)	581.42	0	575.58	0	2227.81	0	3384.81	0
80	2.50%	33-48-**60** (35%)	667.42	0	975.97	0	2788.13	.67	4431.52	.67
	5.00%	33-48-**60** (35%)	667.42	0	975.97	0	2788.13	.67	4431.52	.67
	7.50%	33-42-**60** (35%)	667.42	0	746.39	0	2803.52	.68	4217.33	.68
	10.00%	33-42-**60** (35%)	667.42	0	746.39	0	2803.52	.68	4217.33	.68
	12.50%	30-37-**56** (35%)	568.12	0	571.41	0	2602.62	0	3742.15	0
	15.00%	30-37-**54** (35%)	568.12	0	571.41	0	2420.24	0	3559.77	0
90	2.50%	33-40-**60** (35%)	840.32	0	837.43	0	2716.44	3.72	4394.19	3.72
	5.00%	31-**60** (30%)	632.13	0	-[5]	-	4576.14	2.17	5208.27	2.17
	7.50%	31-**60** (30%)	632.13	0	-	-	4576.14	2.17	5208.27	2.17
	10.00%	31-**60** (35%)	632.13	0	-	-	4576.14	2.17	5208.27	2.17
	12.50%	29-**43** (30%)	566.23	0	-	-	3019.14	0	3585.37	0
	15.00%	29-**39** (30%)	566.23	0	-	-	2501.34	0	3067.57	0

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 84. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	55-**60**[3] (25%)[4]	913.04	0	-[5]	-	3480.23	0	4393.27	0
	5.00%	42-53-**60** (25%)	576.17	0	746.32	0	2993.55	0	4316.04	0
	7.50%	40-55-**60** (30%)	638.38	0	925.81	0	2683.06	0	4247.25	0
	10.00%	40-48-**60** (30%)	638.38	0	701.93	0	2703.10	0	4043.41	0
	12.50%	35-43-**60** (35%)	609.69	0	607.45	0	2382.34	0	3599.48	0
	15.00%	34-42-**60** (35%)	581.24	0	575.58	0	2383.55	0	3944.95	0
80	2.50%	33-48-**60** (35%)	667.42	0	975.97	0	2788.13	.67	4431.52	.67
	5.00%	33-48-**60** (35%)	667.42	0	975.97	0	2788.13	.67	4431.52	.67
	7.50%	33-48-**60** (35%)	667.42	0	975.97	0	2788.13	.67	4431.52	.67
	10.00%	33-48-**60** (35%)	667.42	0	975.97	0	2788.13	.67	4431.52	.67
	12.50%	33-42-**60** (35%)	667.42	0	746.39	0	2803.52	.68	4217.33	.68
	15.00%	33-42-**60** (35%)	667.42	0	746.39	0	2803.52	.68	4217.33	.68
90	2.50%	29-53-**60** (35%)	66.92	0	1412.20	0	2631.21	3.62	4110.33	3.62
	5.00%	33-40-**60** (35%)	840.32	0	837.43	0	2716.44	3.72	4394.19	3.72
	7.50%	31-**60** (30%)	632.13	0	-	-	4576.14	2.17	5208.27	2.17
	10.00%	31-**60** (30%)	632.13	0	-	-	4576.14	2.17	5208.27	2.17
	12.50%	31-**60** (30%)	632.13	0	-	-	4576.14	2.17	5208.27	2.17
	15.00%	31-**60** (30%)	632.13	0	-	-	4576.14	2.17	5208.27	2.17

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 85. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	**60**[3]	-[5]	-	-	-	4394.32	-	4394.32	-
	5.00%	**60**	-	-	-	-	4394.32	-	4394.32	-
	7.50%	**60**	-	-	-	-	4394.32	-	4394.32	-
	10.00%	**60**	-	-	-	-	4394.32	-	4394.32	-
	12.50%	**60**	-	-	-	-	4394.32	-	4394.32	-
	15.00%	**60**	-	-	-	-	4394.32	-	4394.32	-
80	2.50%	**60**	-	-	-	-	5284.32	-	5284.32	-
	5.00%	**60**	-	-	-	-	5284.32	-	5284.32	-
	7.50%	**60**	-	-	-	-	5284.32	-	5284.32	-
	10.00%	**60**	-	-	-	-	5284.32	-	5284.32	-
	12.50%	**60**	-	-	-	-	5284.32	-	5284.32	-
	15.00%	**60**	-	-	-	-	5284.32	-	5284.32	-
90	2.50%	37-52-**60** (25%)	715.13	0	1021.13	0	3569.58	2.78	5305.84	2.78
	5.00%	37-52-**60** (25%)	715.13	0	1021.13	0	3569.58	2.78	5305.84	2.78
	7.50%	37-52-**60** (25%)	715.13	0	1021.13	0	3569.58	2.78	5305.84	2.78
	10.00%	53-**60** (30%)	1494.51	0	-	-	4246.94	1.41	5741.45	1.41
	12.50%	53-**60** (30%)	1494.51	0	-	-	4246.94	1.41	5741.45	1.41
	15.00%	53-**60** (30%)	1494.51	0	-	-	4246.94	1.41	5741.45	1.41

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 86. Volume removed from the financially optimal schedules for white ash plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $50/ton)

Site Index[1]	ARR	Schedule	1st thinning		2nd thinning		Final Harvest		Total Volume	
			Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
70	2.50%	**60**[3]	-[5]	-	-	-	4394.32	-	4394.32	-
	5.00%	**60**	-	-	-	-	4394.32	-	4394.32	-
	7.50%	**60**	-	-	-	-	4394.32	-	4394.32	-
	10.00%	**60**	-	-	-	-	4394.32	-	4394.32	-
	12.50%	**60**	-	-	-	-	4394.32	-	4394.32	-
	15.00%	**60**	-	-	-	-	4394.32	-	4394.32	-
80	2.50%	**60**	-	-	-	-	5284.32	-	5284.32	-
	5.00%	**60**	-	-	-	-	5284.32	-	5284.32	-
	7.50%	**60**	-	-	-	-	5284.32	-	5284.32	-
	10.00%	**60**	-	-	-	-	5284.32	-	5284.32	-
	12.50%	**60**	-	-	-	-	5284.32	-	5284.32	-
	15.00%	**60**	-	-	-	-	5284.32	-	5284.32	-
90	2.50%	37-52-**60** (25%)[4]	715.13	0	1021.13	0	3569.58	2.78	5305.84	2.78
	5.00%	37-52-**60** (25%)	715.13	0	1021.13	0	3569.58	2.78	5305.84	2.78
	7.50%	37-52-**60** (25%)	715.13	0	1021.13	0	3569.58	2.78	5305.84	2.78
	10.00%	**60**	-	-	-	-	6012.54	.75	6012.54	.75
	12.50%	53-**60** (30%)	1494.51	0	-	-	4246.94	1.41	5741.45	1.41
	15.0%	53-**60** (30%)	1494.51	0	-	-	4246.94	1.41	5741.45	1.41

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 87. Financially optimal thinning and final harvest schedules for white ash plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	70	<42-53-**60**[2]>[3] (25%)[4]	55-**60** (25%)	0%	**60**	0%	**60**	0%
	80	<33-48-**60**> (35%)	33-48-**60** (35%)	0%	**60**	0%	**60**	0%
	90	33-40-**60** (35%)	29-53-**60** (35%)	0%	37-52-**60** (25%)	0%	37-52-**60** (25%)	0%
5.00%	70	<40-53-**60**> (30%)	<42-53-**60**> (25%)	0%	**60**	0%	**60**	0%
	80	<33-48-**60**> (35%)	<33-48-**60**> (35%)	0%	**60**	0%	**60**	0%
	90	<31-**60**> (30%)	<33-40-**60**> (35%)	0%	37-52-**60** (25%)	0%	37-52-**60** (25%)	0%
7.50%	70	<34-42-**59**> (35%)	<40-55-**60**> (30%)	2%	**<60>**	2%	<**60**>	2%
	80	<33-42-**60**> (35%)	<33-48-**60**> (35%)	0%	**<60>**	0%	**60**	0%
	90	<31-**60**> (30%)	<31-**60**> (30%)	0%	37-52-**60** (25%)	0%	37-52-**60** (25%)	0%
10.00%	70	<34-42-**59**> (35%)	<40-48-**60**> (30%)	2%	**<60>**	2%	<**60**>	2%
	80	<33-42-**60**> (35%)	<33-48-**60**> (35%)	0%	**<60>**	0%	<**60**>	0%
	90	<31-**60**> (30%)	<31-**60**> (30%)	0%	<53-**60**> (30%)	0%	**60**	0%
12.50%	70	<34-42-**59**> (35%)	<35-43-**60**> (35%)	2%	**<60>**	2%	<**60**>	2%
	80	<30-37-**56**> (35%)	<33-42-**60**> (35%)	7%	**<60>**	7%	<**60**>	7%
	90	<29-**43**> (30%)	<31-**60**> (30%)	40%	<53-**60**> (30%)	40%	<53-**60**> (30%)	40%
15.00%	70	<34-42-**58**> (35%)	<34-42-**60**> (35%)	3%	**<60>**	3%	<**60**>	3%
	80	<30-37-**54**> (35%)	<33-42-**60**> (35%)	11%	**<60>**	11%	<**60**>	11%
	90	<29-**39**> (30%)	<31-**60**> (30%)	54%	<53-**60**> (30%)	54%	<53-**60**> (30%)	54%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

[4]Number in parentheses indicates the percentage of basal area removed during thinning

Table 88. The soil expectation value ($/acre) of the financially optimal rotations for white ash plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	70	-228.56	26.13		730.40		1,070.63	
	80	-105.08	176.80		1,018.23		1,437.47	
	90	359.34	698.08	94%	1,623.92	133%	2,100.80	485%
5.00%	70	-364.36	-242.91		92.73		256.84	
	80	-331.83	-188.17		231.72		440.39	
	90	-227.42	-60.85		434.82		680.34	
7.50%	70	-388.71	-318.60		-119.03		-21.52	
	80	-379.24	-289.07		-29.62		98.31	
	90	-315.13	-214.19		79.56		236.12	
10.00%	70	-395.45	-349.29		-218.14		-154.27	
	80	-392.39	-329.86		153.25		-66.83	
	90	-336.36	-264.30		-66.72		32.47	
12.50%	70	-397.37	-364.34		-271.95		-277.09	
	80	-395.77	-349.95		-221.46		-158.93	
	90	-341.28	-287.06		-137.57		-64.91	
15.00%	70	-397.71	-372.79		-304.13		-270.87	
	80	-396.83	-361.38		-262.98		-215.28	
	90	-342.55	-299.53		-180.99		-123.57	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

Southern- White ash - Timber Only Rotations (C = $0/ton)

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 53 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 71). This optimal management regime will generate the maximum SEV of -$228.56 (Table 79), with a NPW of -$177.88 per acre (Table 75). This means that -$228.56 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$177.88 per acre for managing one rotation, or -$228.56 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 4,316.04 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 33.94 net tons of carbon per acre during one rotation (Table 67). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 71). This optimal management regime will generate the maximum SEV of -$364.36 (Table 79), with a NPW of -$345.78 per acre (Table 75). This financially optimal

rotation would produce an estimated 5,412.95 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 33.15 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 42 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 71). This optimal management regime will generate the maximum SEV of -$388.71 (Table 79), with a NPW of -$383.64 per acre (Table 75). This financially optimal rotation would produce an estimated 3,462.97 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 27.48 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 42 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 71). This optimal management regime will generate the maximum SEV of -$395.45 (Table 79), with a NPW of -$394.15 per acre (Table 75). This financially optimal rotation would produce an estimated 3,462.97 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 27.48 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 42 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 71). This optimal management regime will generate the maximum SEV of -$397.37 (Table 79), with a NPW of -$397.03 per acre (Table 75). This financially optimal rotation would produce an estimated 3,462.97 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 27.48 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 42 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 71). This optimal management regime will generate the maximum SEV of -$397.71 (Table 79), with a NPW of -$397.61 per acre (Table 75). This financially optimal rotation would produce an estimated 3,384.81 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 27.00 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 48 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 71). This optimal management regime will generate the maximum SEV of -$105.08 (Table 79), with a NPW of -$81.78 per acre (Table 75). This financially optimal rotation

would produce an estimated 4,431.52 cubic feet of pulpwood and 0.67 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 36.07 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 48 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 71). This optimal management regime will generate the maximum SEV of -$331.83 (Table 79), with a NPW of -$314.91 per acre (Table 75). This financially optimal rotation would produce an estimated 4,431.52 cubic feet of pulpwood and 0.67 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 36.07 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 42 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 71). This optimal management regime will generate the maximum SEV of -$379.24 (Table 79), with a NPW of -$374.64 per acre (Table 75). This financially optimal rotation would produce an estimated 4,217.33 cubic feet of pulpwood and 0.68 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 34.53 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 42 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 71). This optimal management regime will generate the maximum SEV of -$392.39 (Table 79), with a NPW of -$391.21 per acre (Table 75). This financially optimal rotation would produce an estimated 4,217.33 cubic feet of pulpwood and 0.68 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 34.53 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 37 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 71). This optimal management regime will generate the maximum SEV of -$395.77 (Table 79), with a NPW of -$395.29 per acre (Table 75). This financially optimal rotation would produce an estimated 3,742.15 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 30.00 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 37 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 71). This optimal management regime will generate the maximum SEV of -$396.83 (Table 79), with a NPW of -$396.65 per acre (Table 75). This financially optimal

rotation would produce an estimated 3,559.77 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 28.77 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 40 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 71). This optimal management regime will generate the maximum SEV of $359.34 (Table 79), with a NPW of $279.66 per acre (Table 75). This financially optimal rotation would produce an estimated 4,394.19 cubic feet of pulpwood and 3.72 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 41.04 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 71). This optimal management regime will generate the maximum SEV of -$227.42 (Table 79), with a NPW of -$215.82 per acre (Table 75). This financially optimal rotation would produce an estimated 5,208.27 cubic feet of pulpwood and 2.17 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 35.32 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 71). This optimal management regime will generate the maximum SEV of -$315.13 (Table 79), with a NPW of -$311.31 per acre (Table 75). This financially optimal rotation would produce an estimated 5,208.27 cubic feet of pulpwood and 2.17 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 35.32 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 71). This optimal management regime will generate the maximum SEV of -$336.36 (Table 79), with a NPW of -$335.35 per acre (Table 75). This financially optimal rotation would produce an estimated 5,208.27 cubic feet of pulpwood and 2.17 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 35.32 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 29 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 43 (Table 71). This optimal management regime will generate the maximum SEV of -$341.28 (Table 79), with a NPW of -$339.36 per acre (Table 75). This financially optimal rotation would

produce an estimated 3,585.37 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 24.53 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 29 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 39 (Table 71). This optimal management regime will generate the maximum SEV of -$342.55 (Table 79), with a NPW of -$341.27 per acre (Table 75). This financially optimal rotation would produce an estimated 3,067.57 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 83), and sequester 21.67 net tons of carbon per acre during one rotation (Table 67).

Southern- White ash - Timber + Carbon Rotations (C = $10/ton)

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 55 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of $26.13 (Table 80), with a NPW of $20.34 per acre (Table 76). This means that $26.13 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus \$20.34 per acre for managing one rotation, or \$26.13 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 4,393.27 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 34.13 net tons of carbon per acre during one rotation (Table 68). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 53 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -\$242.91 (Table 80), with a NPW of -\$230.53 per acre (Table 76). This financially optimal rotation would produce an estimated 4,316.04 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 33.94 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 55 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -\$318.60 (Table 80), with a NPW of -\$314.73 per acre (Table 76). This financially optimal rotation would produce an estimated 4,247.25 cubic feet of pulpwood and 0.00 MBF of

sawlogs per acre from the thinning and final harvest (Table 84), and sequester 33.49 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 40 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -$349.29 (Table 80), with a NPW of -$248.24 per acre (Table 76). This financially optimal rotation would produce an estimated 4,043.41 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 32.15 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 43 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -$364.34 (Table 80), with a NPW of -$364.06 per acre (Table 76). This financially optimal rotation would produce an estimated 3,599.48 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 28.49 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 42 (with 35

percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -$372.79 (Table 80), with a NPW of -$372.72 per acre (Table 76). This financially optimal rotation would produce an estimated 3,944.95 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 28.01 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 48 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of $176.80 (Table 80), with a NPW of $137.60 per acre (Table 76). This financially optimal rotation would produce an estimated 4,431.52 cubic feet of pulpwood and 0.67 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 36.07 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 48 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -$188.17 (Table 80), with a NPW of -$178.58 per acre (Table 76). This financially optimal rotation would produce an estimated 4,431.52 cubic feet of pulpwood and 0.67 MBF of

sawlogs per acre from the thinning and final harvest (Table 84), and sequester 36.07 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 48 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -$289.07 (Table 80), with a NPW of -$285.56 per acre (Table 76). This financially optimal rotation would produce an estimated 4,431.52 cubic feet of pulpwood and 0.67 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 36.07 net tons of carbon per acre during one rotation (Table 67).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 48 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -$329.86 (Table 80), with a NPW of -$328.88 per acre (Table 76). This financially optimal rotation would produce an estimated 4,431.52 cubic feet of pulpwood and 0.67 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 36.07 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 42 (with 35

percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -$349.95 (Table 80), with a NPW of -$349.69 per acre (Table 76). This financially optimal rotation would produce an estimated 4,217.33 cubic feet of pulpwood and 0.68 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 34.53 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 42 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -$361.38 (Table 80), with a NPW of -$361.31 per acre (Table 76). This financially optimal rotation would produce an estimated 4,217.33 cubic feet of pulpwood and 0.68 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 34.53 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 53 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of $698.08 (Table 80), with a NPW of $543.28 per acre (Table 76). This financially optimal rotation would produce an estimated 4,110.33 cubic feet of pulpwood and 3.62 MBF of sawlogs

per acre from the thinning and final harvest (Table 84), and sequester 42.81 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 40 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -$60.85 (Table 80), with a NPW of -$57.74 per acre (Table 76). This financially optimal rotation could produce an estimated 4,394.19 cubic feet of pulpwood and 3.72 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 41.04 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest in conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -$214.19 (Table 80), with a NPW of -$211.59 per acre (Table 76). This financially optimal rotation would produce an estimated 5,208.27 cubic feet of pulpwood and 2.17 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 35.32 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -$264.30 (Table 80), with a NPW of -$263.51 per acre (Table 76). This financially optimal rotation would produce an estimated 5,208.27 cubic feet of pulpwood and 2.17 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 35.32 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -$287.06 (Table 80), with a NPW of -$286.84 per acre (Table 76). This financially optimal rotation would produce an estimated 5,208.27 cubic feet of pulpwood and 2.17 MBF of sawlogs per acre from the thinning and final harvest (Table 84), and sequester 35.32 net tons of carbon per acre during one rotation (Table 68).

White ash, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 31 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 72). This optimal management regime will generate the maximum SEV of -$299.53 (Table 80), with a NPW of -$299.47 per acre (Table 76). This financially optimal rotation would produce an estimated 5,208.27 cubic feet of pulpwood and 2.17 MBF of sawlogs per acre

from the thinning and final harvest (Table 84), and sequester 35.32 net tons of carbon per acre during one rotation (Table 68).

<u>Southern- White ash - Timber + Carbon Rotations (C = $37/ton)</u>

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of $730.40 (Table 81), with a NPW of $568.44 per acre (Table 77). This means that $730.40 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $568.44 per acre for managing one rotation, or $730.40 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 4,394.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 33.95 net tons of carbon per acre during one rotation (Table 69). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of $92.73 (Table 81), with a NPW of $88.00 per acre (Table 77). This financially optimal rotation would produce an estimated 4,394.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 33.95 net tons of carbon per acre during one rotation (Table 69).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of -$119.03 (Table 81), with a NPW of -$117.59 per acre (Table 77). This financially optimal rotation would produce an estimated 4,394.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 33.95 net tons of carbon per acre during one rotation (Table 69).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of -$218.14 (Table 81), with a NPW of -$217.49 per acre (Table 77). This financially optimal rotation would produce an estimated 4,394.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 33.95 net tons of carbon per acre during one rotation (Table 69).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 73). This

optimal management regime will generate the maximum SEV of -$271.95 (Table 81), with a NPW of -$271.74 per acre (Table 77). This financially optimal rotation would produce an estimated 4,394.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 33.95 tons of carbon per acre during the rotation (Table 69).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of -$304.13 (Table 81), with a NPW of -$304.07 per acre (Table 77). This financially optimal rotation would produce an estimated 4,394.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 33.95 tons of carbon per acre during the rotation (Table 69).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of $1,018.23 (Table 81), with a NPW of $792.44 per acre (Table 77). This financially optimal rotation would produce an estimated 5,284.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 40.39 net tons of carbon per acre during one rotation (Table 69).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of $231.72 (Table 81), with a NPW of $219.90 per acre (Table 77). This financially optimal rotation would produce an estimated 5,284.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 40.39 net tons of carbon per acre during one rotation (Table 69).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of -$29.62 (Table 81), with a NPW of -$29.26 per acre (Table 77). This financially optimal rotation would produce an estimated 5,284.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 40.39 net tons of carbon per acre during one rotation (Table 69).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of -$153.25 (Table 81), with a NPW of -$152.79 per acre (Table 77). This financially optimal rotation would produce an estimated 5,284.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 40.39 net tons of carbon per acre during one rotation (Table 69).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of -$221.46 (Table 81), with a NPW of -$221.30 per acre (Table 77). This financially optimal rotation would produce an estimated 5,284.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 40.39 net tons of carbon per acre during one rotation (Table 69).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of -$262.98 (Table 81), with a NPW of -$262.93 per acre (Table 77). This financially optimal rotation would produce an estimated 5,284.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 40.39 net tons of carbon per acre during one rotation (Table 69).

White ash, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 52 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of $1,623.92 (Table 81), with a NPW of $1,263.83 per acre (Table 77). This financially optimal rotation would produce an estimated 5,305.84 cubic feet of pulpwood and 2.78 MBF of

sawlogs per acre from the thinning and final harvest (Table 85), and sequester 45.71 net tons of carbon per acre during one rotation (Table 69).

White ash, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 52 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of $434.82 (Table 81), with a NPW of $412.65 per acre (Table 77). This financially optimal rotation would produce an estimated 5,305.84 cubic feet of pulpwood and 2.78 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 45.71 net tons of carbon per acre during one rotation (Table 69).

White ash, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 52 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of $79.56 (Table 81), with a NPW of $78.60 per acre (Table 77). This financially optimal rotation would produce an estimated 5,305.84 cubic feet of pulpwood and 2.78 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 45.71 net tons of carbon per acre during one rotation (Table 69).

White ash, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 53 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of -$66.72 (Table 81), with a NPW of -$66.52 per acre (Table 77). This financially optimal rotation would produce an estimated 5,741.45 cubic feet of pulpwood and 1.41 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 37.02 net tons of carbon per acre during one rotation (Table 69).

White ash, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of -$137.57 (Table 81), with a NPW of -$137.46 per acre (Table 77). This financially optimal rotation would produce an estimated 5,741.45 cubic feet of pulpwood and 1.41 MBF of sawlogs per acre from the thinning and final harvest (Table 85), and sequester 37.02 tons of carbon per acre during one rotation (Table 69).

White ash, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 73). This optimal management regime will generate the maximum SEV of -$180.99 (Table 81), with a NPW of -$180.96 per acre (Table 77). This financially optimal rotation would produce an estimated 5,741.45 cubic feet of pulpwood and 1.41 MBF of sawlogs per acre

from the thinning and final harvest (Table 85), and sequester 37.02 net tons of carbon per acre during one rotation (Table 69).

Southern- White ash - Timber + Carbon Rotations (C = $50/ton)

White ash, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of $1,070.63 (Table 82), with a NPW of $833.23 per acre (Table 78). This means that $1,070.63 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $833.23 per acre for managing one rotation, or $1,070.63 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 4,394.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 33.95 net tons of carbon per acre during one rotation (Table 70). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White ash, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of $256.84 (Table 82), with a NPW of $243.75 per acre (Table 78). This financially optimal rotation would produce an estimated 4,394.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 33.95 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of -$21.52 (Table 82), with a NPW of -$21.26 per acre (Table 78). This financially optimal rotation would produce an estimated 4,394.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 33.95 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of -$154.27 (Table 82), with a NPW of -$153.81 per acre (Table 78). This financially optimal rotation would produce an estimated 4,394.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 33.95 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 74). This

optimal management regime will generate the maximum SEV of -$227.09 (Table 82), with a NPW of -$226.92 per acre (Table 78). This financially optimal rotation would produce an estimated 4,394.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 86), and sequester 33.95 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of -$270.87 (Table 82), with a NPW of -$270.81 per acre (Table 78). This financially optimal rotation would produce an estimated 4,394.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 86), and sequester 33.95 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of $1,437.47 (Table 82), with a NPW of $1,118.73 per acre (Table 78). This financially optimal rotation would produce an estimated 5,284.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 40.39 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of $440.39 (Table 82), with a NPW of $417.93 per acre (Table 78). This financially optimal rotation would produce an estimated 5,284.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 40.39 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of $98.31 (Table 82), with a NPW of $97.12 per acre (Table 78). This financially optimal rotation would produce an estimated 5,284.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 86), and sequester 40.39 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of -$66.83 (Table 82), with a NPW of -$66.63 per acre (Table 78). This financially optimal rotation would produce an estimated 5,284.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 86), and sequester 40.39 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of -$158.93 (Table 82), with a NPW of -$158.81 per acre (Table 78). This financially optimal rotation would produce an estimated 5,284.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 86), and sequester 40.39 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of -$215.28 (Table 82), with a NPW of -$215.23 per acre (Table 78). This financially optimal rotation would produce an estimated 5,284.32 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the final harvest (Table 86), and sequester 40.39 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 52 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of $2,100.80 (Table 82), with a NPW of $1,634.97 per acre (Table 78). This financially optimal rotation would produce an estimated 5,305.84 cubic feet of pulpwood and 2.78 MBF of

sawlogs per acre from the thinning and final harvest (Table 86), and sequester 45.71 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 52 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of $680.34 (Table 82), with a NPW of $645.66 per acre (Table 78). This financially optimal rotation would produce an estimated 5,305.84 cubic feet of pulpwood and 2.78 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 45.71 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 52 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of $236.12 (Table 82), with a NPW of $233.25 per acre (Table 78). This financially optimal rotation would produce an estimated 5,305.84 cubic feet of pulpwood and 2.78 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 45.71 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 74). This

optimal management regime will generate the maximum SEV of $32.47 (Table 82), with a NPW of $32.37 per acre (Table 78). This financially optimal rotation would produce an estimated 6,012.54 cubic feet of pulpwood and 0.75 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 46.88 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of -$64.91 (Table 82), with a NPW of -$64.86 per acre (Table 78). This financially optimal rotation would produce an estimated 5,741.45 cubic feet of pulpwood and 1.41 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 37.02 net tons of carbon per acre during one rotation (Table 70).

White ash, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 74). This optimal management regime will generate the maximum SEV of -$123.57 (Table 82), with a NPW of -$123.54 per acre (Table 78). This financially optimal rotation would produce an estimated 5,741.45 cubic feet of pulpwood and 1.41 MBF of sawlogs per acre from the thinning and final harvest (Table 86), and sequester 37.02 net tons of carbon per acre during one rotation (Table 70).

White fir - *Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.

Biological information

White fir is a highly productive, valuable tree species that ranges from the mountainous regions of the Pacific coast to central Colorado, and from central Oregon and southeastern Idaho to northern Mexico. It grows best in the central Sierra Nevada and has a growth record of 192 ft in height and 106.6 in. in diameter (Silvics Manual□ USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/Volume_1/abies/concolor.htm. July 2, 2006) (Fig.1).

Fig.1 - The native range of California white fir (left) and Rocky Mountain white fir (right) (Silvics Manual. USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/Volume_1/abies/concolor.htm. July 2, 2006).

There are two varieties of white fir: the typical var. *concolor,* white fir, often called Rocky Mountain white fir or Colorado white fir, occupies the eastern and southwestern part of the range; var. *lowiana* (Gord.) Lemm., California white fir or Sierra Nevada white fir, grows in the western range(Silvics Manual. USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/Volume_1/abies/concolor.htm. July 2, 2006).

Site index (base age 50) curves for young-growth California white fir on the western slopes of the Sierra Nevada range from 30 ft to 130 ft (Dolph 1987). Site indexes from 60 to 90 at base age 50 are considered most common in California and eastern Oregon and Washington. The productivity of fully stocked, 100-year-old stands in these areas are shown in Table 1(Silvics Manual USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/Volume_1/abies/concolor.htm. July 2, 2006) (Table 1).

Table 1- Volume in white fir stands in California, eastern Oregon and Washington at age 100

Site index[1] and location	Basal area		Volume	
27.4 m or 90 ft	*m²/ha*	*ft²/acre*	*m³/ha*	*ft³/acre*
California	108	471	1,372	19,600
Oregon and Washington	80	349	1,066	15,230
18.3 m or 60 ft				
California	91	397	805	11,500
Oregon and Washington	67	291	633	9,039

[1]Average height of dominant trees at base age 50 years.

White Fir wood is soft, knotty and not very strong; it is used extensively for solid construction framing, plywood, and paper making. White Fir is widely planted as an ornamental tree in large parks. It smells great and has sturdy branches, which hold their shape well, thus the tree is also often used as a Christmas tree (Silvics Manual USDA Forest Service. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/Volume_1/abies/concolor.htm. July 2, 2006).

Economic information

Haight (1991) present an adaptive management formulation for determining the timing and intensity of thinning and the time of clearcut for stands with any structure and with stochastic log prices for California White fir. The formulation was solved by using two different white fir stands with a site index of 70 ft (base age 100) in California for starting conditions. The numerical analysis used a stage-structured growth and yield model for this tree species that is constructed using growth equations developed by Wensel et al (1987). The model uses density-dependent, nonlinear functions for predicting regeneration, growth and survival. The results revealed that the size of the trees in the initial stand played a more critical role than price variation in determining the relative economic returns.

Speechly and Helms (1985) conducted an economic analysis of precommercial thinning and its impacts on growth and economic returns in non-uniform white fir stands in California. The study was done on 8-ha, 30-60 year-old white fir stands in the Sierra Nevada in northern California. Six types of group were recognized, distinguished in terms of average stem diameter and within-group tree density by measuring 50 plots in a semi-systematic manner. Alternative thinning treatments were compared on the basis of the ranking of present net value. The results showed that precommercial thinning could be a highly profitable operation and might give a net increase in the stand's present net worth of up to $970 per hectare.

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Species___White fir______ Region Inland California, Southern Cascades

Site indices 100, 110 and 120 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 4.5-in. inside bark top diameter for trees with a minimum of 7 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 9-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 15 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.187943262 and 0.709219858, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Westman (1987) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$\ln Y = 4.36982 + 2.5043 \ln X$$

where:

Y = total aboveground mass (kg)

X = diameter at breast height (cm)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.6% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $153/mbf (Scribner) (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices) and pulpwood price was assumed to be $0/cord (USDA Forest Service, Timber and log price reports. The number was the average for Washington, Oregon and California. http://www.srs.fs.usda.gov/econ/data/prices). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of white fir plantations in the Southern Cascades of Inland California.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$80.28	Only once	Year 0	
Seedlings[b] (600 seedlings/ac)	$108	Only Once	Year 0	
Burning[a]	$21.24	Every 5 years	Year 10	Final Harvest
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al (2005).

[b]The seedling cost was estimated based on the seedling prices from California Department of Forestry & Fire Protection. Magalia Reforestation Center. Bareroot seedling price list 2004 - 2005. (http://www.fire.ca.gov/php/rsrc-mgt_content/downloads/Orderformandpricelist04_05.pdf. December 12, 2005).

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Table 1. Total tons of carbon sequestered per acre for white fir plantations by site index and real alternative rates of return in California. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	85.31	51.44	47.10	47.10	31.78	31.78
110	82.30	38.46	36.64	36.64	36.64	36.64
120	102.31	46.34	42.01	35.06	35.06	35.06

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for white fir plantations by site index and real alternative rates of return in California. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	85.31	51.44	47.10	47.10	31.78	31.78
110	108.54	38.46	36.64	36.64	36.64	36.64
120	103.89	46.34	42.01	37.27	35.06	35.06

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for white fir plantations by site index and real alternative rates of return in California. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	93.36	55.74	51.44	47.10	47.10	47.10
110	115.12	72.70	47.52	36.64	36.64	36.64
120	111.47	73.83	46.34	42.01	42.01	35.06

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for white fir plantations by site index and real alternative rates of return in California. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	93.36	79.07	53.80	51.44	47.10	47.10
110	115.12	81.26	73.61	47.52	36.64	36.64
120	111.47	73.83	46.34	42.01	42.01	42.01

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white fir plantations by site index and real alternative rates of return in California. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	27-33-**47**[2] (20%)[3]	25-**30** (30%)	23-**28** (30%)	23-**28** (30%)	<16-**21>**[4] (30%)	<16-**21>** (30%)
110	28-**44** (30%)	16-**23** (20%)	17-**22** (20%)	17-**22** (20%)	<17-**22>** (20%)	<17-**22>** (20%)
120	29-42-**54** (30%)	**25**	**23**	**20**	**<20>**	**<20>**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white fir plantations by site index and real alternative rates of return in California. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	27-33-**47**[2] (20%)[3]	25-**30** (30%)	23-**28** (30%)	23-**28** (30%)	<16-**21**>[4] (30%)	<16-**21**> (30%)
110	28-44-**59** (30%)	16-**23** (20%)	17-**22** (20%)	17-**22** (20%)	17-**22** (20%)	<17-**22**> (20%)
120	29-40-**54** (25%)	**25**	**23**	**21**	**20**	<**20**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white fir plantations by site index and real alternative rates of return in California. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	27-36-**51**[2] (20%)[3]	27-**32** (30%)	25-**30** (30%)	23-**28** (30%)	23-**28** (30%)	23-**28** (30%)
110	29-41-**62** (25%)	26-**39** (30%)	22-**27** (30%)	17-**22** (20%)	17-**22** (20%)	17-**22** (20%)
120	29-40-**58** (25%)	25-**38** (30%)	**25**	**23**	**23**	**20**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white fir plantations by site index and real alternative rates of return in California. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	27-36-**51**[2] (20%)[3]	26-36-**44** (25%)	26-**31** (30%)	25-**30** (30%)	23-**28** (30%)	23-**28** (30%)
110	29-41-**62** (25%)	25-30-**43** (20%)	25-30-**40** (25%)	22-**27** (30%)	17-**22** (20%)	17-**22** (20%)
120	29-40-**58** (25%)	25-**38** (30%)	**25**	**23**	**23**	**23**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for white fir plantations by site index and real alternative rates of return in California. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$3,346.52	$991.15	$331.67	$9.42	-$133.05	-$215.71
110	$3,684.70	$1,037.00	$446.71	$126.02	-$63.09	-$175.79
120	$4,533.93	$1,235.12	$537.21	$171.77	-$19.88	-$139.50

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for white fir plantations by site index and real alternative rates of return in California. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$3,938.31	$1,300.21	$559.93	$190.28	-$11.00	-$113.72
110	$4,930.90	$1,293.59	$650.38	$294.09	$76.43	-$59.18
120	$5,226.40	$1,539.49	$768.11	$350.94	$124.64	-$17.24

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for white fir plantations by site index and real alternative rates of return in California. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$5,770.15	$2,207.47	$1,206.22	$678.60	$376.97	$186.05
110	$6,980.41	$2,633.46	$1,298.67	$747.89	$453.14	$255.68
120	$7,369.94	$2,833.87	$1,431.74	$869.71	$535.47	$312.86

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for white fir plantations by site index and real alternative rates of return in California. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$6,591.67	$2,947.82	$1,533.95	$927.17	$565.25	$338.53
110	$7,935.92	$3,242.36	$1,763.90	$1,020.82	$634.52	$407.27
120	$8,321.81	$3,360.64	$1,751.18	$1,116.26	$739.36	$484.80

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for white fir plantations by site index and real alternative rates of return in California. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$4,819.79	$1,271.29	$378.10	$10.05	-$143.83	-$226.16
110	$5,492.79	$1,503.05	$551.15	$141.86	-$67.59	-$183.15
120	$6,103.43	$1,718.41	$652.17	$198.60	-$21.72	-$147.33

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for white fir plantations by site index and real alternative rates of return in California. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$5,672.11	$1,667.70	$638.31	$203.08	-$11.89	-$119.23
110	$6,381.20	$1,874.96	$802.44	$331.06	$81.88	-$61.66
120	$7,035.61	$2,141.87	$932.48	$400.08	$136.12	-$18.21

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for white fir plantations by site index and real alternative rates of return in California. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$7,979.99	$2,758.90	$1,349.62	$724.26	$389.78	$189.34
110	$8,847.78	$3,069.46	$1,496.15	$841.91	$485.48	$266.38
120	$9,608.36	$3,330.63	$1,689.45	$967.98	$569.17	$330.41

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for white fir plantations by site index and real alternative rates of return in California. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
100	$9,116.14	$3,316.98	$1,702.19	$978.13	$584.45	$344.51
110	$10,058.90	$3,671.41	$1,859.77	$1,096.88	$679.80	$424.32
120	$10,849.33	$3,949.73	$2,066.38	$1,242.39	$785.89	$502.35

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for white fir plantations by soil productivity and real alternative rates of return in California). (carbon value = $0/ton)

Site Index[1]	ARR	Schedule	1st thinning MBF[2]	2nd thinning MBF	Final harvest MBF	Total volume MBF
100	2.50%	27-33-**47**[3] (20%)[4]	4.36	8.58	62.02	74.96
	5.00%	25-**30** (30%)	6.72	-	32.93	39.65
	7.50%	23-**28** (30%)	4.81	-	30.52	35.33
	10.00%	23-**28** (30%)	4.81	-	30.52	35.33
	12.50%	16-**21** (30%)	0	-	19.42	19.42
	15.00%	16-**21** (30%)	0	-	19.42	19.42
110	2.50%	28-**44** (30%)	11.10	-	65.89	76.99
	5.00%	16-**23** (20%)	0	-	30.50	30.50
	7.50%	17-**22** (20%)	0	-	28.29	28.29
	10.00%	17-**22** (20%)	0	-	28.29	28.29
	12.50%	17-**22** (20%)	0	-	28.29	28.29
	15.00%	17-**22** (20%)	0	-	28.29	28.29
120	2.50%	29-42-**54** (30%)	12.38	20.03	76.07	108.48
	5.00%	**25**	-	-	38.30	38.30
	7.50%	**23**	-	-	33.60	33.60
	10.00%	**20**	-	-	25.62	25.62
	12.50%	**20**	-	-	25.62	25.62
	15.00%	**20**	-	-	25.62	25.62

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 18. Volume removed from the financially optimal schedules for white fir plantations by soil productivity and real alternative rates of return in California. (carbon value = $10/ton)

			1st thinning	2nd thinning	Final harvest	Total volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
100	2.50%	27-33-**47**[3] (20%)[4]	4.36	8.58	62.02	74.96
	5.00%	25-**30** (30%)	6.72	-	32.93	39.65
	7.50%	23-**28** (30%)	4.81	-	30.52	35.33
	10.00%	23-**28** (30%)	4.81	-	30.52	35.33
	12.50%	16-**21** (30%)	0	-	19.42	19.42
	15.00%	16-**21** (30%)	0	-	19.42	19.42
110	2.50%	28-44-**59** (30%)	11.10	19.58	80.84	111.52
	5.00%	16-**23** (20%)	0	-	30.50	30.50
	7.50%	17-**22** (20%)	0	-	28.29	28.29
	10.00%	17-**22** (20%)	0	-	28.29	28.29
	12.50%	17-**22** (20%)	0	-	28.29	28.29
	15.00%	17-**22** (20%)	0	-	28.29	28.29
120	2.50%	29-40-**54** (25%)	9.98	15.96	84.50	110.44
	5.00%	**25**	-	-	38.30	38.30
	7.50%	**23**	-	-	33.60	33.60
	10.00%	**21**	-	-	28.19	28.19
	12.50%	**20**	-	-	25.62	25.62
	15.00%	**20**	-	-	25.62	25.62

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for white fir plantations by soil productivity and real alternative rates of return in California. (carbon value = $37/ton)

			1st thinning	2nd thinning	Final harvest	Total volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
100	2.50%	27-36-**51**[3] (20%)[4]	4.36	9.31	69.98	83.65
	5.00%	27-**32** (30%)	8.74	-	34.72	43.46
	7.50%	25-**30** (30%)	6.72	-	32.93	39.65
	10.00%	23-**28** (30%)	4.81	-	30.52	35.33
	12.50%	23-**28** (30%)	4.81	-	30.52	35.33
	15.00%	23-**28** (30%)	4.81	-	30.52	35.33
110	2.50%	29-41-**62** (25%)	9.47	14.54	97.88	121.89
	5.00%	26-**39** (30%)	9.43	-	54.72	64.15
	7.50%	22-**27** (30%)	5.06	-	31.75	36.81
	10.00%	17-**22** (20%)	0	-	28.29	28.29
	12.50%	17-**22** (20%)	0	-	28.29	28.29
	15.00%	17-**22** (20%)	0	-	28.29	28.29
120	2.50%	29-40-**58** (25%)	9.98	15.96	96.36	122.30
	5.00%	25-**38** (30%)	8.98	-	58.69	67.67
	7.50%	**25**	-	-	38.30	38.30
	10.00%	**23**	-	-	33.66	33.66
	12.50%	**23**	-	-	33.66	33.66
	15.00%	**20**		-	25.62	25.62

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for white fir plantations by soil productivity and real alternative rates of return in California. (carbon value = $50/ton)

			1st thinning	2nd thinning	Final harvest	Total volume
Site Index[1]	ARR	Schedule	MBF[2]	MBF	MBF	MBF
100	2.50%	27-36-**51**[3] (20%)[4]	4.36	9.31	69.98	83.65
	5.00%	26-36-**44** (25%)	5.94	11.11	49.55	66.60
	7.50%	26-**31** (30%)	8.09	-	33.31	41.40
	10.00%	25-**30** (30%)	6.72	-	32.93	39.65
	12.50%	23-**28** (30%)	4.81	-	30.52	35.33
	15.00%	23-**28** (30%)	4.81	-	30.52	35.33
110	2.50%	29-41-**62** (25%)	9.47	14.54	97.88	121.89
	5.00%	25-30-**43** (20%)	4.10	8.47	61.55	74.12
	7.50%	25-30-**40** (25%)	6.35	9.64	48.08	64.07
	10.00%	22-**27** (30%)	5.06	-	31.75	36.81
	12.50%	17-**22** (20%)	0	-	28.29	28.29
	15.00%	17-**22** (20%)	0	-	28.29	28.29
120	2.50%	29-40-**58** (25%)	9.98	15.96	96.36	122.30
	5.00%	25-**38** (30%)	8.98	-	58.69	67.67
	7.50%	**25**	-	-	38.30	38.30
	10.00%	**23**	-	-	33.66	33.66
	12.50%	**23**	-	-	33.66	33.66
	15.00%	**23**		-	33.66	33.66

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for white fir plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	100	27-33-**47**[2] (20%)[3]	27-33-**47**[2] (20%)[3]	0%	27-36-**51**[2] (20%)[3]	9%	27-36-**51**[2] (20%)[3]	9%
	110	28-**44** (30%)	28-44-**59** (30%)	34%	29-41-**62** (25%)	41%	29-41-**62** (25%)	41%
	120	29-42-**54** (30%)	29-40-**54** (25%)	0%	29-40-**58** (25%)	7%	29-40-**58** (25%)	7%
5.00%	100	25-**30** (30%)	25-**30** (30%)	0%	27-**32** (30%)	7%	26-36-**44** (25%)	47%
	110	16-**23** (20%)	16-**23** (20%)	0%	26-**39** (30%)	70%	25-30-**43** (20%)	87%
	120	**25**	**25**	0%	25-**38** (30%)	52%	25-**38** (30%)	52%
7.50%	100	23-**28** (30%)	23-**28** (30%)	0%	25-**30** (30%)	7%	26-**31** (30%)	11%
	110	17-**22** (20%)	17-**22** (20%)	0%	22-**27** (30%)	23%	25-30-**40** (25%)	82%
	120	**23**	**23**	0%	**25**	9%	**25**	9%
10.00%	100	23-**28** (30%)	23-**28** (30%)	0%	23-**28** (30%)	0%	25-**30** (30%)	7%
	110	17-**22** (20%)	17-**22** (20%)	0%	17-**22** (20%)	0%	22-**27** (30%)	23%
	120	**20**	**21**	5%	**23**	15%	**23**	15%
12.50%	100	<16-**21**>[4] (30%)	<16-**21**>[4] (30%)	0%	23-**28** (30%)	33%	23-**28** (30%)	33%
	110	<17-**22**> (20%)	17-**22** (20%)	0%	17-**22** (20%)	0%	17-**22** (20%)	0%
	120	<**20**>	**20**	0%	**23**	15%	**23**	15%
15.00%	100	<16-**21**> (30%)	<16-**21**> (30%)	0%	23-**28** (30%)	33%	23-**28** (30%)	33%
	110	<17-**22**> (20%)	<17-**22**> (20%)	0%	17-**22** (20%)	0%	17-**22** (20%)	0%
	120	<**20**>	<**20**>	0%	**20**	0%	**23**	15%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning
[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for white fir plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	100	4,819.79	5,672.11	18%	12,744.51	66%	13,057.85	89%
	110	5,492.79	6,381.20	16%	14,540.79	61%	14,884.22	83%
	120	6,103.43	7,035.61	15%	16,110.17	57%	16,534.13	78%
5.00%	100	1,271.29	1,667.70	31%	4,965.30	117%	5,142.85	161%
	110	1,503.05	1,874.96	25%	5,782.16	104%	5,979.62	144%
	120	1,718.41	2,141.87	25%	6,321.38	94%	6,536.54	130%
7.50%	100	378.10	638.31	69%	2,507.64	257%	2,636.55	350%
	110	551.15	802.44	46%	2,999.14	171%	3,144.65	237%
	120	652.17	932.48	43%	3,353.45	159%	3,514.05	217%
10.00%	100	10.05	203.08	1921%	1,372.02	7107%	1,474.44	9633%
	110	141.86	331.06	133%	1,702.54	493%	1,819.89	673%
	120	198.60	400.08	101%	1,959.30	387%	2,090.51	526%
12.50%	100	-143.83	-11.89		756.18		841.29	
	110	-67.59	81.88		992.21		1,091.19	
	120	-21.72	136.12		1,187.65		1,299.75	
15.00%	100	-226.16	-119.23		391.98		464.62	
	110	-183.15	-61.66		567.22		652.94	
	120	-147.33	-18.21		720.50		818.80	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>California- White fir - Timber Only Rotations (C = $0/ton)</u>

White fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 33 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 47 (Table 5). This optimal management regime will generate the maximum SEV of $4,819.79 (Table 13), with a NPW of $3,346.52 per acre (Table 9). This means that $4,819.79 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $3,346.52 per acre for managing one rotation, or $4,819.79 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 74.96 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 85.31 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 30 (Table 5). This optimal management regime will generate the maximum SEV of $1,271.29 (Table 13), with a NPW of $991.15 per acre (Table 9). This financially optimal rotation would

produce an estimated 39.65 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 51.44 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 23 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 28 (Table 5). This optimal management regime will generate the maximum SEV of $378.10 (Table 13), with a NPW of $331.67 per acre (Table 9). This financially optimal rotation would produce an estimated 35.33 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 47.10 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 23 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 28 (Table 5). This optimal management regime will generate the maximum SEV of $10.05 (Table 13), with a NPW of $9.42 per acre (Table 9). This financially optimal rotation would produce an estimated 35.33 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 47.10 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 16 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 21 (Table 5). This optimal management regime will generate the maximum SEV of -$143.83 (Table 13),

with a NPW of -$133.05 per acre (Table 9). This financially optimal rotation would produce an estimated 19.42 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 31.78 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 216 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 21 (Table 5). This optimal management regime will generate the maximum SEV of -$226.16 (Table 13), with a NPW of -$215.71 per acre (Table 9). This financially optimal rotation would produce an estimated 19.42 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 31.78 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 28 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 44 (Table 5). This optimal management regime will generate the maximum SEV of $5,492.79 (Table 13), with a NPW of $3,684.70 per acre (Table 9). This financially optimal rotation would produce an estimated 76.99 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 82.30 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 16 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 23 (Table 5). This

optimal management regime will generate the maximum SEV of $1,503.05 (Table 13), with a NPW of $1,037.00 per acre (Table 9). This financially optimal rotation would produce an estimated 30.50 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 38.46 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 5). This optimal management regime will generate the maximum SEV of $551.15 (Table 13), with a NPW of $446.71 per acre (Table 9). This financially optimal rotation would produce an estimated 28.29 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 36.64 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 5). This optimal management regime will generate the maximum SEV of $141.86 (Table 13), with a NPW of $126.02 per acre (Table 9). This financially optimal rotation would produce an estimated 28.29 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 36.64 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of

basal area removed) and a final harvest is conducted at stand age 22 (Table 5). This optimal management regime will generate the maximum SEV of -$67.59 (Table 13), with a NPW of -$63.09 per acre (Table 9). This financially optimal rotation would produce an estimated 28.29 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 36.64 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 5). This optimal management regime will generate the maximum SEV of -$183.15 (Table 13), with a NPW of -$175.79 per acre (Table 9). This financially optimal rotation would produce an estimated 28.29 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 36.64 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 42 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 5). This optimal management regime will generate the maximum SEV of $6,103.43 (Table 13), with a NPW of $4,533.93 per acre (Table 9). This financially optimal rotation would produce an estimated 108.48 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 102.31 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 5). This optimal management regime will generate the maximum SEV of $1,718.41 (Table 13), with a NPW of $1,235.12 per acre (Table 9). This financially optimal rotation would produce an estimated 38.30 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 46.34 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 5). This optimal management regime will generate the maximum SEV of $652.17 (Table 13), with a NPW of $537.21 per acre (Table 9). This financially optimal rotation would produce an estimated 33.60 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 42.01 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 5). This optimal management regime will generate the maximum SEV of $198.60 (Table 13), with a NPW of $171.77 per acre (Table 9). This financially optimal rotation would produce an estimated 25.62 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 35.06 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 5). This

optimal management regime will generate the maximum SEV of -$21.72 (Table 13), with a NPW of -$19.88 per acre (Table 9). This financially optimal rotation would produce an estimated 25.62 MBF of sawlogs per acre from the final harvest (Table 17), and sequester 35.06 net tons of carbon per acre during one rotation (Table 1).

White fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 5). This optimal management regime will generate the maximum SEV of -$147.33 (Table 13), with a NPW of -$139.50 per acre (Table 9). This financially optimal rotation would produce an estimated 25.62 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 35.06 net tons of carbon per acre during one rotation (Table 1).

<u>California- White fir - Timber Only Rotations (C = $10/ton)</u>

White fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 33 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 47 (Table 6). This optimal management regime will generate the maximum SEV of $5,672.11 (Table 14), with a NPW of $3,938.31 per acre (Table 10). This means that $5,672.11 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $3,938.31 per acre for managing one rotation, or $5,672.11 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 74.96 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 85.31 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 30 (Table 6). This optimal management regime will generate the maximum SEV of $1,667.70 (Table 14), with a NPW of $1,300.21 per acre (Table 10). This financially optimal rotation would produce an estimated 39.65 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 51.44 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 23 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 28 (Table 6). This optimal management regime will generate the maximum SEV of $638.31 (Table 14), with a NPW of $559.93 per acre (Table 10). This financially optimal rotation would produce an estimated 25.33 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 47.10 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 23 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 28 (Table 6). This optimal management regime will generate the maximum SEV of $203.08 (Table 14), with a NPW of $190.28 per acre (Table 10). This financially optimal rotation would produce an estimated 35.33 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 47.10 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 16 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 21 (Table 6). This optimal management regime will generate the maximum SEV of -$11.89 (Table 14), with a NPW of -$11.00 per acre (Table 10). This financially optimal rotation would produce an estimated 19.42 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 31.78 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 16 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 21 (Table 6). This optimal management regime will generate the maximum SEV of -$119.23 (Table 14), with a NPW of -$113.72 per acre (Table 10). This financially optimal rotation would produce an estimated 19.42 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 31.78 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 28 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 6). This optimal management regime will generate the maximum SEV of $6,381.20 (Table 14), with a NPW of $4,930.90 per acre (Table 10). This financially optimal rotation would produce an estimated 111.52 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 108.54 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 16 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 23 (Table 6). This optimal management regime will generate the maximum SEV of $1,874.96 (Table 14), with a NPW of $1,293.59 per acre (Table 10). This financially optimal rotation would produce an estimated 30.50 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 38.46 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 6). This optimal management regime will generate the maximum SEV of $802.44 (Table 14), with a NPW of $650.38 per acre (Table 10). This financially optimal rotation would

produce an estimated 28.29 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 36.64 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 6). This optimal management regime will generate the maximum SEV of $331.06 (Table 14), with a NPW of $294.09 per acre (Table 10). This financially optimal rotation would produce an estimated 28.29 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 36.64 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 6). This optimal management regime will generate the maximum SEV of $81.88 (Table 14), with a NPW of $76.43 per acre (Table 10). This financially optimal rotation would produce an estimated 28.29 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 36.64 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 6). This optimal management regime will generate the maximum SEV of -$61.66 (Table 14), with

a NPW of -$59.18 per acre (Table 10). This financially optimal rotation would produce an estimated 28.29 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 36.64 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 40 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 6). This optimal management regime will generate the maximum SEV of $7,035.61 (Table 14), with a NPW of $5,226.40 per acre (Table 10). This financially optimal rotation would produce an estimated 110.44 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 103.89 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 6). This optimal management regime will generate the maximum SEV of $2,141.87 (Table 14), with a NPW of $1,539.49 per acre (Table 10). This financially optimal rotation would produce an estimated 38.30 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 46.34 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 6). This optimal management regime will generate the maximum SEV of $932.48 (Table 14), with a NPW of $768.11 per acre (Table 10). This financially optimal rotation would produce an estimated 33.60 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 42.01 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 21 (Table 6). This optimal management regime will generate the maximum SEV of $400.08 (Table 14), with a NPW of $350.94 per acre (Table 10). This financially optimal rotation would produce an estimated 28.19 MBF of sawlogs per acre from the final harvest (Table 181), and sequester 37.27 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 6). This optimal management regime will generate the maximum SEV of $136.12 (Table 14), with a NPW of $124.64 per acre (Table 10). This financially optimal rotation would produce an estimated 25.62 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 35.06 net tons of carbon per acre during one rotation (Table 2).

White fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 6). This optimal management regime will generate the maximum SEV of -$18.21 (Table 14), with a NPW of -$17.24 per acre (Table 10). This financially optimal rotation would produce

an estimated 25.62 MBF of sawlogs per acre from the final harvest (Table 18), and sequester 35.06 net tons of carbon per acre during one rotation (Table 2).

<u>California-White fir - Timber Only Rotations (C = $37/ton)</u>

White fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 36 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 7). This optimal management regime will generate the maximum SEV of $7,979.99 (Table 15), with a NPW of $5,770.15 per acre (Table 11). This means that $7,979.99 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $5,770.15 per acre for managing one rotation, or $7,979.99 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 83.65 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 93.36 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 27 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 32 (Table 7). This optimal management regime will generate the maximum SEV of $2,758.90 (Table 15), with a NPW of $2,207.47 per acre (Table 11). This financially optimal rotation would produce an estimated 43.46 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 55.74 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 30 (Table 7). This optimal management regime will generate the maximum SEV of $1,349.62 (Table 15), with a NPW of $1,206.22 per acre (Table 11). This financially optimal rotation would produce an estimated 39.65 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 51.44 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 23 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 28 (Table 7). This optimal management regime will generate the maximum SEV of $724.26 (Table 15), with a NPW of $678.60 per acre (Table 11). This financially optimal rotation would produce an estimated 35.33 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 47.10 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 23 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 28 (Table 7). This optimal management regime will generate the maximum SEV of $389.78 (Table 15), with a NPW of $376.97 per acre (Table 11). This financially optimal rotation would produce an estimated 35.33 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 47.10 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 23 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 28 (Table 7). This optimal management regime will generate the maximum SEV of $189.34 (Table 15), with a NPW of $186.05 per acre (Table 11). This financially optimal rotation would produce an estimated 35.33 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 47.10 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 41 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 62 (Table 7). This optimal management regime will generate the maximum SEV of $8,847.78 (Table 15), with a NPW of $6,980.41 per acre (Table 11). This financially optimal rotation would produce an estimated 121.89 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 115.12 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 39 (Table 7). This optimal management regime will generate the maximum SEV of $3,069.46 (Table 15), with a NPW of $2,633.46 per acre (Table 11). This financially optimal rotation would produce an estimated 64.15 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 72.70 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 22 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 7). This optimal management regime will generate the maximum SEV of $1,496.15 (Table 15), with a NPW of $1,298.67 per acre (Table 11). This financially optimal rotation would produce an estimated 36.81 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 47.52 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 7). This optimal management regime will generate the maximum SEV of $841.91 (Table 15),

with a NPW of $747.89 per acre (Table 11). This financially optimal rotation would produce an estimated 28.29 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 36.64 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 7). This optimal management regime will generate the maximum SEV of $485.48 (Table 15), with a NPW of $453.14 per acre (Table 11). This financially optimal rotation would produce an estimated 28.29 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 36.64 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 7). This optimal management regime will generate the maximum SEV of $266.38 (Table 15), with a NPW of $255.68 per acre (Table 11). This financially optimal rotation would produce an estimated 28.29 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 36.64 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 40 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 7).

This optimal management regime will generate the maximum SEV of $9,608.36 (Table 15), with a NPW of $7,369.94 per acre (Table 11). This financially optimal rotation would produce an estimated 122.30 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 111.47 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 38 (Table 7). This optimal management regime will generate the maximum SEV of $3,330.63 (Table 15), with a NPW of $2,833.87 per acre (Table 11). This financially optimal rotation would produce an estimated 67.67 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 73.83 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 7). This optimal management regime will generate the maximum SEV of $1,689.45 (Table 15), with a NPW of $1,431.74 per acre (Table 11). This financially optimal rotation would produce an estimated 38.30 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 46.34 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 7). This

optimal management regime will generate the maximum SEV of $967.98 (Table 15), with a NPW of $869.71 per acre (Table 11). This financially optimal rotation would produce an estimated 33.66 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 42.01 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 7). This optimal management regime will generate the maximum SEV of $569.17 (Table 15), with a NPW of $535.47 per acre (Table 11). This financially optimal rotation would produce an estimated 33.66 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 42.01 net tons of carbon per acre during one rotation (Table 3).

White fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 20 (Table 7). This optimal management regime will generate the maximum SEV of $330.41 (Table 15), with a NPW of $312.86 per acre (Table 11). This financially optimal rotation would produce an estimated 25.62 MBF of sawlogs per acre from the final harvest (Table 19), and sequester 35.06 net tons of carbon per acre during one rotation (Table 3).

<u>California- White fir - Timber Only Rotations (C = $50/ton)</u>

White fir, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 36 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 8). This optimal management regime will generate the maximum SEV of $9,116.14 (Table 16), with a NPW of $6,591.67 per acre (Table 12). This means that $9,116.14 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 100 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $6,591.67 per acre for managing one rotation, or $9,116.14 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 83.65 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 93.36 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White fir, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 36 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 44 (Table 8). This optimal management regime will generate the maximum SEV of $3,316.98 (Table 16), with a NPW of $2,947.82 per acre (Table 12). This financially optimal rotation would produce an estimated 66.60 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 79.07 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 26 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 31 (Table 8). This optimal management regime will generate the maximum SEV of $1,702.19 (Table 16), with a NPW of $1,533.95 per acre (Table 12). This financially optimal rotation would produce an estimated 41.40 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 53.80 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 30 (Table 8). This optimal management regime will generate the maximum SEV of $978.13 (Table 16), with a NPW of $927.17 per acre (Table 12). This financially optimal rotation would produce an estimated 39.65 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 51.44 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 23 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 28 (Table 8). This optimal management regime will generate the maximum SEV of $584.45 (Table 16), with a NPW of $565.25 per acre (Table 12). This financially optimal rotation would produce an estimated 35.33 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 47.10 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 23 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 28 (Table 8). This optimal management regime will generate the maximum SEV of $344.51 (Table 16), with a NPW of $338.53 per acre (Table 12). This financially optimal rotation would produce an estimated 35.33 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 47.10 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 41 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 62 (Table 8). This optimal management regime will generate the maximum SEV of $10,058.90 (Table 16), with a NPW of $7,935.92 per acre (Table 12). This financially optimal rotation would produce an estimated 121.89 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 115.12 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 30 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 43 (Table 8). This optimal management regime will generate the maximum SEV of $3,671.41 (Table 16), with a NPW of $3,242.36 per acre (Table 12). This financially optimal rotation

would produce an estimated 74.12 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 81.26 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 30 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 40 (Table 8). This optimal management regime will generate the maximum SEV of $1,859.77 (Table 16), with a NPW of $1,763.90 per acre (Table 12). This financially optimal rotation would produce an estimated 64.07 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 73.61 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 22 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 27 (Table 8). This optimal management regime will generate the maximum SEV of $1,096.88 (Table 16), with a NPW of $1,020.82 per acre (Table 12). This financially optimal rotation would produce an estimated 36.81 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 47.52 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of

basal area removed) and a final harvest is conducted at stand age 22 (Table 8). This optimal management regime will generate the maximum SEV of $679.80 (Table 16), with a NPW of $634.52 per acre (Table 12). This financially optimal rotation would produce an estimated 28.29 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 36.64 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 17 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 22 (Table 8). This optimal management regime will generate the maximum SEV of $424.32 (Table 16), with a NPW of $407.27 per acre (Table 12). This financially optimal rotation would produce an estimated 28.29 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 36.64 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 120 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 40 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 8). This optimal management regime will generate the maximum SEV of $10,849.33 (Table 16), with a NPW of $8,321.81 per acre (Table 12). This financially optimal rotation would produce an estimated 122.30 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 111.47 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 120 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 25 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 38 (Table 8). This optimal management regime will generate the maximum SEV of $3,949.73 (Table 16), with a NPW of $3,360.64 per acre (Table 12). This financially optimal rotation would produce an estimated 67.67 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 73.83 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 120 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 25 (Table 8). This optimal management regime will generate the maximum SEV of $2,066.38 (Table 16), with a NPW of $1,751.18 per acre (Table 12). This financially optimal rotation would produce an estimated 38.30 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 46.34 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 120 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 8). This optimal management regime will generate the maximum SEV of $1,242.39 (Table 16), with a NPW of $1,116.26 per acre (Table 12). This financially optimal rotation would produce an estimated 33.66 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 42.01 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 120 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 8). This optimal management regime will generate the maximum SEV of $785.89 (Table 16), with a NPW of $739.36 per acre (Table 12). This financially optimal rotation would produce an estimated 33.66 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 42.01 net tons of carbon per acre during one rotation (Table 4).

White fir, Site Index 120 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 23 (Table 8). This optimal management regime will generate the maximum SEV of $502.35 (Table 16), with a NPW of $484.80 per acre (Table 12). This financially optimal rotation would produce an estimated 33.66 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 42.01 net tons of carbon per acre during one rotation (Table 4).

White oak - *Quercus alba* L.

Biological information

White oak is a commercially important hardwood which is widespread across eastern North America. One of the easiest ways to tell a white oak is by the white gray bark with shallow irregular scales. It can grow well in almost all types of habitats except the driest shallow soils. You will find it grows largest on fertile bottomlands and moist, rich slopes (Silvics manual, USDA Forest Service http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/quercus/alba.htm. April 28, 2006).

White oak grows throughout the eastern United States from Southwestern Maine, west to central Michigan and southeastern Minnesota; south to eastern Texas; and east to Florida and Georgia. It grows best on the western slopes of the Appalachian Mountains and the Ohio and Central Mississippi River Valleys. However, the biggest trees on record were found in Delaware and Maryland on the Eastern Shore (Silvics manual, USDA Forest Service http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/quercus/alba.htm. April 28, 2006) (Fig.1).

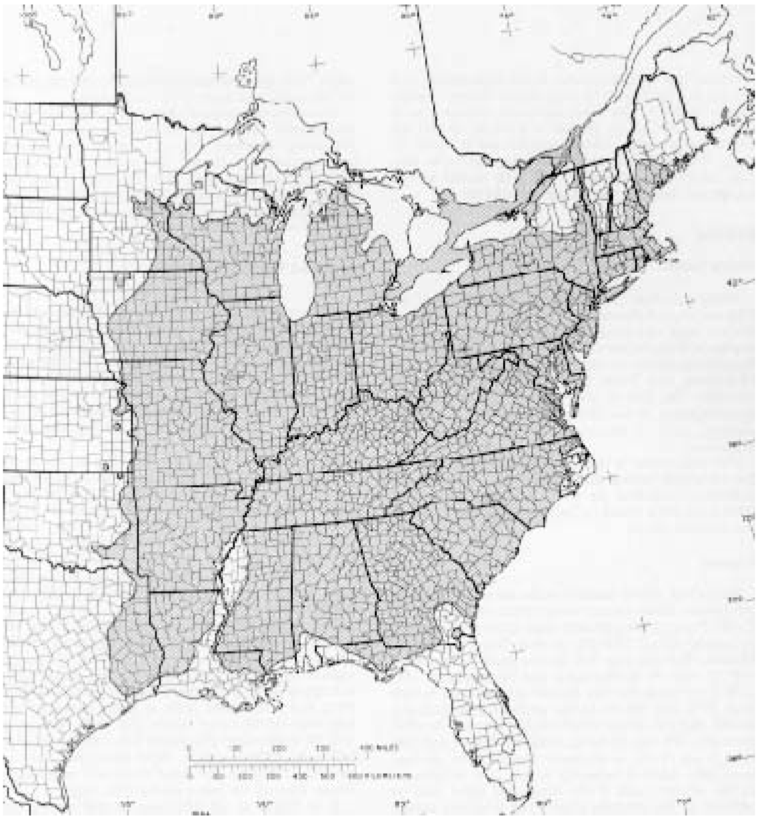

Fig.1. The native range of white oak (Silvics manual, USDA Forest Service http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/quercus/alba.htm. April 28, 2006).

White oak is a large, long-lived tree that can grow from 80 to 100 feet tall, 36 to 48 inches in diameter, with crown spread from 50 to 80 feet. (Silvics manual, USDA Forest Service http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/quercus/alba.htm. April 28, 2006).

White oak is very slow growing among all non-oak trees only hickory and beech demonstrate a slower growth rate. According to the data from Forest Resources Evaluation data in the Central States, the average 10 year dbh growth rate of white oak was 1.20 in. for seedlings, 1.37 in. for poles, and 1.84 in. for sawtimber (Silvics manual, USDA Forest Service

http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/quercus/alba.htm. April 28, 2006).

Pure and mixed unthinned stands at age 80 normally contain 2000 to 12,000 mbf/acre of wood, and mean annual volume growth in these stands ranges from 68 to 156 mbf/acre/yr depending on site quality (Silvics manual. USDA For. Serv. http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/quercus/alba.htm April 28, 2006.).

The rotation length of white oak can be very long (120+ years), but it can be reduced by 50% with dramatically increased yields if the stands are thinned early and regularly. If thinnings are begun at age 10 and stands re-thinned every 10 years to 60% stocking, volume yield at age 60 can reach 18,840 mbf/acre on good sites, which almost doubled that in similar unthinned stands. Mean annual growth in thinned, good stands is 279 mbf/acre/yr (Silvics manual, USDA Forest Service http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/quercus/alba.htm. April 28, 2006).

Site index for white oak is generally less than for yellow-poplar and other oaks in the same site. No detailed site indexes ranges were provided (Silvics manual, USDA Forest Service http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/quercus/alba.htm. April 28, 2006).

White oak is valued for its timber products such as furniture, flooring and cabinet making, barrel making, interior finishes, and for heavy construction, such as railroad ties. The tree also produces acorns, which are a food source for wildlife. It is sometimes also planted as an ornamental tree because of its broad crown, dense foliage and fall coloration (Silvics manual, USDA Forest Service http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/quercus/alba.htm. April 28, 2006).

Economic information

Countryman and Murrow (2000) conducted an economic analysis of contour tree buffer strips using row cropping, terracing, conventional tillage, contour strip-cropping, and the Conservation Reserve Program. Four tree species were planted in buffer strips: ash, black walnut, red oak and white oak. Net present value (NPV) calculations and sensitivity analysis were carried out on land values, real interest rates, and the projected costs and revenues under different scenarios to analyze the feasibility of contour buffer strips as a soil conservation practice. The results showed that black walnut generated the greatest profitability, followed by red oak, white oak and ash. The authors concluded that the contour tree buffer strips are an economically feasible conservation alternative for soil erosion on agricultural lands that have a low land value and low crop yield.

Bernardo et al (1992) studied optimal vegetation management under multiple-use objectives in the cross timbers of North America. A mathematical model was developed to derive economically efficient vegetation management programs for large herbivore production in the cross timbers of Central Oklahoma to evaluate alternative means of increasing large herbivore production. Two management scenarios were developed to evaluate the influence of multiple-use objectives on optimal vegetation management programs. The results showed that economic returns from the land resource can be increased approximately 46% by conducting the multiple-enterprise management program.

Literature cited

Bernardo D.J., D.M. Engle, R.L. Lochmiller and F.T. McCollum. 1992. Optimal vegetation management under multiple-use objectives in the cross timbers. J. Range Man. 45:462-469.

Countryman D.W. and J.C. Murrow. 2002 Economic analysis of contour tree buffer strips using present net value. J. Soil and Water Conserv. V55(2). P 152-160.

Species ___white oak_________ Region ______Central States_________________

Site indices 60, 70 and 80 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 5.40, 6.00, and 7.20 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 25 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183482143 and 0.446428571, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Myers et al (1980) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$Y = 2.00678D^{2.47164}H^{0.00113}$$

where:

Y = the green weight of the total tree (lb.)

D = diameter at breast height (in.)

H = total tree height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be \$130/mbf (International 1/4) (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005) and pulpwood price was assumed to be \$16/cord (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005). The price of carbon was assumed to be \$0, \$10, \$37 or \$50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of white oak plantations in the Central States.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$218	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]The seedling cost was estimated based on the seedling prices from Ohio DNR State Forest Nursery (http://www.ohiodnr.com/forestry/seedling/list.htm. January 18, 2006) and Lee's Nursery, Inc. (http://www.leenursery.com/Seedling2006Catalog.pdf. January 18, 2006).

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Table 1. Total tons of carbon sequestered per acre for white oak plantations in the central United States by site index and real alternative rates of return. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	26.06	25.23	23.09	21.84	21.84	21.84
70	26.87	24.53	23.42	23.02	22.11	21.34
80	27.88	24.70	23.04	22.70	22.35	20.92

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for white oak plantations in the central United States by site index and real alternative rates of return. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	26.06	26.06	25.36	23.84	23.84	23.54
70	27.62	25.78	24.53	24.17	23.82	23.82
80	27.88	25.98	23.71	23.46	22.79	22.45

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for white oak plantations in the central United States by site index and real alternative rates of return. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	26.02	25.99	25.99	25.99	23.05	22.67
70	27.40	27.42	26.89	25.76	25.67	22.61
80	28.79	28.79	28.82	27.35	25.98	24.18

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for white oak plantations in the central United States by site index and real alternative rates of return. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	25.99	25.99	25.99	23.05	23.05	22.67
70	27.40	26.89	25.76	25.86	22.61	22.61
80	28.79	28.82	27.35	27.42	27.42	21.13

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white oak plantations by site index and real alternative rates of return in the central United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<52-60-**90**[2]>[3] (30%)[4]	<52-57-**88>** (20%)	<52-57-**82**> (20%)	<52-57-**77**> (30%)	<52-57-**77**> (30%)	<52-57-**77**> (30%)
70	<47-56-**88>** (30%)	<47-56-**80**> (30%)	<47-53-**79**> (30%)	<47-53-**78**> (30%)	<47-53-**74**> (30%)	<47-53-**72**> (30%)
80	<42-48-**89**> (30%)	<42-48-**79**> (30%)	<41-47-**76**> (30%)	<46-51-**74**> (25%)	<41-47-**73**> (30%)	<41-47-**68**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white oak plantations by site index and real alternative rates of return in the central United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<52-60-**90**[2]>[3] (30%)[4]	<52-60-**90**> (30%)	<52-60-**88**> (30%)	<52-60-**82**> (30%)	<52-60-**82**> (30%)	<68-**82**> (30%)
70	<47-56-**90**> (30%)	<47-56-**85**> (30%)	<47-56-**80**> (30%)	<47-56-**79**> (30%)	<47-56-**78**> (30%)	<47-56-**78**> (30%)
80	<42-48-**89**> (30%)	<43-51-**82**> (30%)	<43-52-**76**> (30%)	<43-51-**74**> (30%)	<41-49-**75**> (30%)	<41-48-**73**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white oak plantations by site index and real alternative rates of return in the central United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<67-**90**[2]>[3] (30%)[4]	<69-84-**90**> (20%)	<69-84-**90**> (20%)	<69-85-**90**> (20%)	<84-**90**> (30%)	<85-**90**> (30%)
70	65-71-**90** (20%)	<65-72-**90**> (20%)	<68-85-**90**> (20%)	<66-**90**> (20%)	<72-**90**> (20%)	<85-**90**> (20%)
80	62-85-**90** (30%)	<62-85-**90>** (30%)	<63-84-**90**> (30%)	<63-85-**90**> (20%)	<65-**89**> (20%)	<78-**88**> (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white oak plantations by site index and real alternative rates of return in the central United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	69-84-**90**[2] (20%)[3]	<69-84-**90**>[4] (20%)	<69-85-**90**> (20%)	<84-**90**> (30%)	<84-**90**> (30%)	<83-**90**> (30%)
70	65-71-**90** (20%)	68-85-**90** (20%)	<66-**90**> (20%)	<71-**90**> (20%)	<85-**90**> (20%)	<85-**90**> (20%)
80	62-85-**90** (30%)	63-84-**90** (30%)	<63-85-**90**> (20%)	<65-85-**90**> (20%)	<65-85-**90**> (20%)	**80**

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the central United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$286.95	-$448.54	-$465.60	-$466.33	-$465.31	-$464.28
70	-$240.45	-$437.06	-$462.98	-$465.71	-$465.08	-$464.20
80	-$178.83	-$425.68	-$459.36	-$465.19	-$464.64	-$464.00

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the central United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$131.98	-$369.56	-$421.65	-$439.19	-$447.18	-$451.41
70	-$76.34	-$353.32	-$413.88	-$434.66	-$443.97	-$448.93
80	-$6.80	-$336.51	-$407.16	-$430.92	-$441.54	-$447.15

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the central United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$303.08	-$143.23	-$297.41	-$364.10	-$397.65	-$416.46
70	$391.19	-$107.63	-$275.60	-$348.79	-$386.18	-$407.44
80	$491.67	-$74.90	-$258.22	-$337.25	-$377.83	-$401.07

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the central United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$517.39	-$33.28	-$237.36	-$327.85	-$373.78	-$399.63
70	$620.55	$12.98	-$208.07	-$307.20	-$358.29	-$387.44
80	$734.00	$53.62	-$184.98	-$291.66	-$347.02	-$378.84

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the central United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$320.87	-$454.45	-$466.75	-$466.60	-$465.36	-$464.29
70	-$270.49	-$445.63	-$464.40	-$465.96	-$465.15	-$464.21
80	-$200.56	-$434.45	-$461.12	-$465.56	-$464.71	-$464.04

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the central United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$147.59	-$373.98	-$422.33	-$439.35	-$447.20	-$451.41
70	-$85.36	-$358.73	-$415.07	-$434.87	-$444.01	-$448.94
80	-$7.62	-$342.48	-$408.72	-$431.26	-$441.59	-$447.16

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the central United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$338.91	-$144.94	-$297.82	-$364.16	-$397.66	-$416.46
70	$437.43	-$108.91	-$275.98	-$348.85	-$386.19	-$407.44
80	$549.79	-$75.80	-$258.58	-$337.31	-$377.84	-$401.07

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the central United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$578.55	-$33.68	-$237.69	-$327.91	-$373.79	-$399.63
70	$693.90	$13.13	-$208.36	-$307.25	-$358.29	-$387.44
80	$820.77	$54.26	-$185.24	-$291.71	-$347.03	-$378.84

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for white oak plantations by soil productivity and real alternative rates of return in the central United States. (carbon value = $0/ton)

Site Index[1]	ARR	Schedule	1st thinning		2nd thinning		Final Harvest		Total Volume	
			Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.50%	<52-60-**90**[3]> (30%)[4]	556.90	0	614.74	0	1,607.63	10.47	2,779.27	10.47
	5.00%	<52-57-**88**> (20%)	556.90	0	569.54	0	1,625.61	9.67	2,752.05	9.67
	7.50%	<52-57-**82**> (20%)	556.90	0	569.54	0	1,673.20	7.03	2,799.64	7.03
	10.00%	<52-57-**77**> (30%)	556.90	0	569.54	0	1,724.57	5.23	2,851.01	5.23
	12.50%	<52-57-**77**> (30%)	556.90	0	569.54	0	1,724.57	5.23	2,851.01	5.23
	15.00%	<52-57-**77**> (30%)	556.90	0	569.54	0	1,724.57	5.23	2,851.01	5.23
70	2.50%	<47-56-**88**> (30%)	590.89	0	628.62	0	1,853.30	12.23	3,072.81	12.23
	5.00%	<47-56-**80**> (30%)	590.89	0	628.62	0	1,822.38	9.34	3,041.89	9.34
	7.50%	<47-53-**79**> (30%)	590.89	0	565.68	0	1,803.52	8.58	2,960.09	8.58
	10.00%	<47-53-**78**> (30%)	590.89	0	565.68	0	1,825.17	8.05	2,981.74	8.05
	12.50%	<47-53-**74**> (30%)	590.89	0	565.68	0	2,077.52	5.73	3,234.09	5.73
	15.00%	<47-53-**72**> (30%)	896.75	0	-[5]	-	2,215.81	6.02	3,112.56	6.02
80	2.50%	<42-48-**89**> (30%)	585.78	0	613.65	0	1,956.43	16.05	3,155.86	16.05
	5.00%	<42-48-**79**> (30%)	585.78	0	613.65	0	2,069.25	11.14	3,268.68	11.14
	7.50%	<41-47-**76**> (30%)	555.31	0	586.83	0	2,007.47	9.69	3,149.61	9.69
	10.00%	<46-51-**74**> (25%)	566.13	0	584.05	0	2,273.87	7.84	3,424.05	7.84
	12.50%	<41-47-**73**> (30%)	555.31	0	586.83	0	2,217.00	7.68	3,359.14	7.68
	15.00%	<41-47-**68**> (30%)	555.31	0	586.83	0	2,464.35	4.41	3,606.49	4.41

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 18. Volume removed from the financially optimal schedules for white oak plantations by soil productivity and real alternative rates of return in the central United States. (carbon value = $10/ton)

Site Index[1]	ARR	Schedule	1st thinning		2nd thinning		Final Harvest		Total Volume	
			Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.50%	<52-60-**90**[3]> (30%)[4]	556.90	0	614.74	0	1,607.63	10.47	2,779.27	10.47
	5.00%	<52-60-**90**> (30%)	556.90	0	614.74	0	1,607.63	10.47	2,779.27	10.47
	7.50%	<52-60-**88**> (30%)	556.90	0	614.74	0	1,605.97	9.62	2,777.61	9.62
	10.00%	<52-60-**82**> (30%)	556.90	0	614.74	0	1,718.89	7.19	2,890.53	7.19
	12.50%	<52-60-**82**> (30%)	556.90	0	614.74	0	1,718.89	7.19	2,890.53	7.19
	15.00%	<68-**90**> (30%)	896.75	0	-[5]	-	2,215.81	6.02	3,112.56	6.02
70	2.50%	<47-56-**90**> (30%)	590.89	0	628.62	0	1,897.17	12.78	3,116.68	12.78
	5.00%	<47-56-**85**> (30%)	590.89	0	628.62	0	1,777.75	11.21	2,997.26	11.21
	7.50%	<47-56-**80**> (30%)	590.89	0	628.62	0	1,822.38	9.34	3,041.89	9.34
	10.00%	<47-56-**79**> (30%)	590.89	0	628.62	0	1,856.76	8.80	3,076.27	8.80
	12.50%	<47-56-**78**> (30%)	590.89	0	628.62	0	1,882.49	8.25	3,102.00	8.25
	15.00%	<47-56-**78**> (30%)	590.89	0	628.62	0	1,882.49	8.25	3,102.00	8.25
80	2.50%	<42-48-**89**> (30%)	585.78	0	613.65	0	1,956.43	16.05	3,155.86	16.05
	5.00%	<43-51-**82**> (30%)	623.45	0	682.29	0	2,004.49	12.82	3,310.23	12.82
	7.50%	<43-52-**76**> (30%)	623.45	0	701.88	0	1,993.56	9.74	3,318.89	9.74
	10.00%	<43-51-**74**> (30%)	623.45	0	682.29	0	2,178.07	8.55	3,483.81	8.55
	12.50%	<41-49-**75**> (30%)	555.31	0	659.46	0	2,037.85	9.03	3,252.62	9.03
	15.00%	<41-48-**73**> (30%)	555.31	0	623.85	0	2,212.43	7.68	3,391.59	7.68

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for white oak plantations by soil productivity and real alternative rates of return in the central United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.50%	<67-**90**[3]> (30%)[4]	870.01	0	-[5]	-	2054.38	9.82	2,924.39	9.82
	5.00%	<69-84-**90**> (20%)	604.12	0	637.59	0	1731.46	9.47	2,973.17	9.47
	7.50%	<69-84-**90**> (20%)	604.12	0	637.59	0	1731.46	9.47	2,973.17	9.47
	10.00%	<69-85-**90**> (20%)	604.12	0	666.08	0	1750.83	9.30	3,021.03	9.30
	12.50%	<84-**90**> (30%)	979.42	0	-	-	1611.24	8.78	2,590.66	8.78
	15.00%	<85-**90**> (30%)	983.00	0	-	-	1565.44	8.62	2,548.44	8.62
70	2.50%	<65-71-**90**> (20%)	614.90	0	633.56	0	1,984.21	12.29	3,232.67	12.29
	5.00%	<65-72-**90**> (20%)	623.92	0	640.67	0	1,980.98	12.11	3,245.57	12.11
	7.50%	<68-85-**90**> (20%)	653.10	0	715.4	0.12	1,836.46	11.55	3,204.96	11.66
	10.00%	<66-**90**> (20%)	623.92	0	-	-	2,385.72	11.42	3,009.64	11.42
	12.50%	<72-**90**> (20%)	710.01	0	-	-	2,331.93	11.57	3,041.94	11.57
	15.00%	<85-**90**> (20%)	739.50	0	-	-	1,871.73	10.59	2,611.23	10.59
80	2.50%	62-85-**90** (30%)	1,077.56	0	885.69	2.37	1,462.20	13.45	3,425.45	15.81
	5.00%	<62-85-**90>** (30%)	1,077.56	0	885.69	2.37	1,462.20	13.45	3,425.45	15.81
	7.50%	<63-84-**90**> (30%)	1,094.39	0	905.57	2.12	1,466.54	13.48	3,466.50	15.60
	10.00%	<63-85-**90**> (20%)	728.94	0	773.05	0.36	1,846.89	14.25	3,348.88	14.61
	12.50%	<65-**89**> (20%)	734.56	0	-	-	2,364.32	14.20	3,098.88	14.20
	15.00%	<78-**88**> (20%)	792.07	0	-	-	2,057.48	13.48	2,849.55	13.48

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for white oak plantations by soil productivity and real alternative rates of return in the central United States. (carbon value = $50/ton)

Site Index[1]	ARR	Schedule	1st thinning		2nd thinning		Final Harvest		Total Volume	
			Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.50%	69-84-**90**[3] (20%)[4]	604.12	0	637.59	0	1,731.46	9.47	2,973.17	9.47
	5.00%	<69-84-**90**> (20%)	604.12	0	637.59	0	1,731.46	9.47	2,973.17	9.47
	7.50%	<69-85-**90**> (20%	604.12	0	666.08	0	1,750.83	9.30	3,021.03	9.30
	10.00%	<84-**90**> (30%)	979.42	0	-[5]	-	1,611.24	8.78	2,590.66	8.78
	12.50%	<84-**90**> (30%)	979.42	0	-	-	1,611.24	8.78	2,590.66	8.78
	15.00%	<83-**90**> (30%)	983.00	0	-	-	1,565.44	8.62	2,548.44	8.62
70	2.50%	65-71-**90** (20%)	614.90	0	633.56	0	1,984.21	12.29	3,232.67	12.29
	5.00%	68-85-**90** (20%)	653.10	0	715.40	0.12	1,836.46	11.55	3,204.96	11.66
	7.50%	<66-**90**> (20%)	623.92	0	-	-	2,385.72	11.42	3,009.64	11.42
	10.00%	<71-**90**> (20%)	692.21	0	-	-	2,362.47	11.61	3,054.68	11.61
	12.50%	<85-**90**> (20%)	739.50	0	-	-	1,871.73	10.59	2,611.23	10.59
	15.00%	<85-**90**> (20%)	739.50	0	-	-	1,871.73	10.59	2,611.23	10.59
80	2.50%	62-85-**90** (30%)	1,077.56	0	885.69	2.37	1,462.20	13.45	3,425.45	15.81
	5.00%	63-84-**90** (30%)	1,094.39	0	905.57	2.12	1,466.54	13.48	3,466.50	15.60
	7.50%	<63-85-**90**> (20%)	728.94	0	773.05	0.36	1,846.89	14.25	3,348.88	14.61
	10.00%	<65-85-**90**> (20%)	734.56	0	767.35	0.39	1,844.24	14.26	3,346.15	14.65
	12.50%	<65-85-**89**> (20%)	734.56	0	767.35	0.39	1,844.24	14.26	3,346.15	14.65
	15.0%	**80**	-	-	-	-	3,015.71	8.42	3,015.71	8.42

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for white oak plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	60	<52-60-**90**[2]>[3] (30%)[4]	<52-60-**90**> (30%)	0%	<67-**90**> (30%)	0%	69-84-**90** (20%)	0%
	70	<47-56-**88>** (30%)	<47-56-**90**> (30%)	2%	65-71-**90** (20%)	2%	65-71-**90** (20%)	2%
	80	<42-48-**89**> (30%)	<42-48-**89**> (30%)	0%	62-85-**90** (30%)	1%	62-85-**90** (30%)	1%
5.00%	60	<52-57-**88>** (20%)	<52-60-**90**> (30%)	2%	<69-84-**90**> (20%)	2%	<69-84-**90**> (20%)	2%
	70	<47-56-**80**> (30%)	<47-56-**85**> (30%)	6%	<65-72-**90**> (20%)	13%	68-85-**90** (20%)	13%
	80	<42-48-**79**> (30%)	<43-51-**82**> (30%)	4%	<62-85-**90>** (30%)	14%	63-84-**90** (30%)	14%
7.50%	60	<52-57-**82**> (20%)	<52-60-**88**> (30%)	7%	<69-84-**90**> (20%)	10%	<69-85-**90**> (20%)	10%
	70	<47-53-**79**> (30%)	<47-56-**80**> (30%)	1%	<68-85-**90**> (20%)	14%	<66-**90**> (20%)	14%
	80	<41-47-**76**> (30%)	<43-52-**76**> (30%)	0%	<63-84-**90**> (30%)	18%	<63-85-**90**> (20%)	18%
10.00%	60	<52-57-**77**> (30%)	<52-60-**82**> (30%)	6%	<69-85-**90**> (20%)	17%	<84-**90**> (30%)	17%
	70	<47-53-**78**> (30%)	<47-56-**79**> (30%)	1%	<66-**90**> (20%)	15%	<71-**90**> (20%)	15%
	80	<46-51-**74**> (25%)	<43-51-**74**> (30%)	0%	<63-85-**90**> (20%)	22%	<65-85-**90**> (20%)	22%
12.50%	60	<52-57-**77**> (30%)	<52-60-**82**> (30%)	6%	<84-**90**> (30%)	17%	<84-**90**> (30%)	17%
	70	<47-53-**74**> (30%)	<47-56-**78**> (30%)	5%	<72-**90**> (20%)	22%	<85-**90**> (20%)	22%
	80	<41-47-**73**> (30%)	<41-49-**75**> (30%)	3%	<65-**89**> (20%)	22%	<65-85-**90**> (20%)	23%
15.00%	60	<52-57-**77**> (30%)	<68-**82**> (30%)	6%	<85-**90**> (30%)	17%	<83-**90**> (30%)	17%
	70	<47-53-**72**> (30%)	<47-56-**78**> (30%)	8%	<85-**90**> (20%)	25%	<85-**90**> (20%)	25%
	80	<41-47-**68**> (30%)	<41-48-**73**> (30%)	7%	<78-**88**> (20%)	29%	**80**	18%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

[4]Number in parentheses indicates the percentage of basal area removed during thinning

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for white oak plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	60	-320.87	-147.59		338.91		578.55	
	70	-270.49	-85.36		437.43		693.90	
	80	-200.56	-7.62		549.79		820.77	
5.00%	60	-454.45	-373.98		-144.94		-33.68	
	70	-445.63	-358.73		-108.91		13.13	
	80	-434.45	-342.48		-75.80		54.26	
7.50%	60	-466.75	-422.33		-297.82		-237.69	
	70	-464.40	-415.07		-275.98		-208.36	
	80	-461.12	-408.72		-258.58		-185.24	
10.00%	60	-466.60	-439.35		-364.16		-327.91	
	70	-465.96	-434.87		-348.85		-307.25	
	80	-465.56	-431.26		-337.31		-291.71	
12.50%	60	-465.36	-447.20		-397.66		-373.79	
	70	-465.15	-444.01		-386.19		-358.29	
	80	-464.71	-441.59		-377.84		-347.03	
15.00%	60	-464.29	-451.41		-416.46		-399.63	
	70	-464.21	-448.94		-407.44		-387.44	
	80	-464.04	-447.16		-401.07		-378.84	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

Central States- White oak - Timber Only Rotations (C = $0/ton)

White oak, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 60 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$320.87 (Table 13), with a NPW of -$286.95 per acre (Table 9). This means that -$320.87 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$286.95 per acre for managing one rotation, or -$320.87 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,779.27 cubic feet of pulpwood and 10.47 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 26.06 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White oak, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 57 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 5). This optimal management regime will generate the maximum SEV of -$454.45 (Table 13), with a NPW of -$448.54 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,752.05 cubic feet of pulpwood and 9.67 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 25.23 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 57 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 5). This optimal management regime will generate the maximum SEV of -$466.75 (Table 13), with a NPW of -$465.60 per acre (Table 9). This financially optimal rotation would produce an estimated 2,799.64 cubic feet of pulpwood and 7.03 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.09 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 57 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 5). This optimal management regime will generate the maximum SEV of -$466.60 (Table 13), with a NPW of -$466.33 per acre (Table 9). This financially optimal rotation would produce an estimated 2,851.01 cubic feet of pulpwood and 5.23 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 21.84 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 57 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 5). This optimal management regime will generate the maximum SEV of -$465.36 (Table 13), with a NPW of -$465.31 per acre (Table 9). This financially optimal rotation would produce an estimated 2,851.01 cubic feet of pulpwood and 5.23 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 21.84 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 57 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 5). This optimal management regime will generate the maximum SEV of -$464.29 (Table 13), with a NPW of -$464.28 per acre (Table 9). This financially optimal rotation would produce an estimated 2,851.01 cubic feet of pulpwood and 5.23 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 21.84 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 5). This optimal management regime will generate the maximum SEV of -$270.49 (Table 13), with a NPW of -$240.45 per acre (Table 9). This financially optimal rotation would

produce an estimated 3,072.81 cubic feet of pulpwood and 12.23 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 26.87 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 5). This optimal management regime will generate the maximum SEV of -$445.63 (Table 13), with a NPW of -$437.06 per acre (Table 9). This financially optimal rotation would produce an estimated 3,041.89 cubic feet of pulpwood and 9.34 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 24.53 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 5). This optimal management regime will generate the maximum SEV of -$464.40 (Table 13), with a NPW of -$462.98 per acre (Table 9). This financially optimal rotation would produce an estimated 2,960.09 cubic feet of pulpwood and 8.58 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.42 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 78 (Table 5). This optimal management regime will generate the maximum SEV of -$465.96 (Table 13), with a NPW of -$465.71 per acre (Table 9). This financially optimal rotation would produce an estimated 2,981.74 cubic feet of pulpwood and 8.05 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.02 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 5). This optimal management regime will generate the maximum SEV of -$465.15 (Table 13), with a NPW of -$465.08 per acre (Table 9). This financially optimal rotation would produce an estimated 3,234.09 cubic feet of pulpwood and 5.73 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.11 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 53 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 72 (Table 5). This optimal management regime will generate the maximum SEV of -$464.21 (Table 13), with a NPW of -$464.20 per acre (Table 9). This financially optimal rotation would

produce an estimated 3,112.56 cubic feet of pulpwood and 6.02 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 21.34 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 5). This optimal management regime will generate the maximum SEV of -$200.56 (Table 13), with a NPW of -$178.83 per acre (Table 9). This financially optimal rotation would produce an estimated 3,155.86 cubic feet of pulpwood and 16.05 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 27.88 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 5). This optimal management regime will generate the maximum SEV of -$434.45 (Table 13), with a NPW of -$425.68 per acre (Table 9). This financially optimal rotation would produce an estimated 3,268.68 cubic feet of pulpwood and 11.14 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 24.70 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 5). This optimal management regime will generate the maximum SEV of -$461.12 (Table 13), with a NPW of -$459.36 per acre (Table 9). This financially optimal rotation would produce an estimated 3,149.61 cubic feet of pulpwood and 9.69 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.04 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 51 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 5). This optimal management regime will generate the maximum SEV of -$465.56 (Table 13), with a NPW of -$465.19 per acre (Table 9). This financially optimal rotation would produce an estimated 3,424.05 cubic feet of pulpwood and 7.84 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.70 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 73 (Table 5). This optimal management regime will generate the maximum SEV of -$464.71 (Table 13), with a NPW of -$464.64 per acre (Table 9). This financially optimal rotation would

produce an estimated 3,359.14 cubic feet of pulpwood and 7.68 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.35 net tons of carbon per acre during one rotation (Table 1).

White oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 68 (Table 5). This optimal management regime will generate the maximum SEV of -$464.04 (Table 13), with a NPW of -$464.00 per acre (Table 9). This financially optimal rotation would produce an estimated 3,606.49 cubic feet of pulpwood and 4.41 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 20.92 net tons of carbon per acre during one rotation (Table 1).

<u>Central States- White oak - Timber Only Rotations (C = $10/ton)</u>

White oak, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 60 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$147.59 (Table 14), with a NPW of -$131.98 per acre (Table 10). This means that -$147.59 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on

every dollar invested plus -$131.98 per acre for managing one rotation, or -$147.59 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,779.27 cubic feet of pulpwood and 10.47 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.06 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White oak, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 60 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -$373.98 (Table 14), with a NPW of -$369.56 per acre (Table 10). This financially optimal rotation would produce an estimated 2,779.27 cubic feet of pulpwood and 10.47 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.06 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 60 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 6). This optimal management regime will generate the maximum SEV of -$422.33 (Table 14), with a NPW of -$421.65 per acre (Table 10). This financially optimal rotation would produce an estimated 2,777.61 cubic feet of pulpwood and 9.62 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 25.36 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 60 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 6). This optimal management regime will generate the maximum SEV of -$439.35 (Table 14), with a NPW of -$439.19 per acre (Table 10). This financially optimal rotation would produce an estimated 2,890.53 cubic feet of pulpwood and 7.19 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.84 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 52 and 60 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 6). This optimal management regime will generate the maximum SEV of -$447.20 (Table 14), with a NPW of -$447.18 per acre (Table 10). This financially optimal rotation would produce an estimated 2,890.53 cubic feet of pulpwood and 7.19 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.84 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 68 (with 30 percent of

basal area removed) and a final harvest is conducted at stand age 82 (Table 6). This optimal management regime will generate the maximum SEV of -\$451.41 (Table 14), with a NPW of -\$451.41 per acre (Table 10). This financially optimal rotation would produce an estimated 3,112.56 cubic feet of pulpwood and 6.02 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.54 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of -\$85.36 (Table 14), with a NPW of -\$76.34 per acre (Table 10). This financially optimal rotation would produce an estimated 3,116.68 cubic feet of pulpwood and 12.78 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 27.62 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = \$10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 85 (Table 6). This optimal management regime will generate the maximum SEV of -\$358.73 (Table 14), with a NPW of -\$353.32 per acre (Table 10). This financially optimal rotation would produce an estimated 2,997.26 cubic feet of pulpwood and 11.21 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 25.78 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 6). This optimal management regime will generate the maximum SEV of -$415.07 (Table 14), with a NPW of -$413.88 per acre (Table 10). This financially optimal rotation would produce an estimated 3,041.89 cubic feet of pulpwood and 9.34 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 24.53 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 79 (Table 6). This optimal management regime will generate the maximum SEV of -$434.87 (Table 14), with a NPW of -$434.66 per acre (Table 10). This financially optimal rotation would produce an estimated 3,076.27 cubic feet of pulpwood and 8.80 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 24.17 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 56 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 78 (Table 6). This optimal management regime will generate the maximum SEV of -$444.01 (Table 14), with a NPW of -$443.97 per acre (Table 10). This financially optimal rotation would produce an estimated 3,102.00 cubic feet of pulpwood and 8.25 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.82 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 47 and 56 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 78 (Table 6). This optimal management regime will generate the maximum SEV of -$448.94 (Table 14), with a NPW of -$448.93 per acre (Table 10). This financially optimal rotation would produce an estimated 3,102.00 cubic feet of pulpwood and 8.25 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.82 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 42 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$7.62 (Table 14), with a NPW of -$6.80 per acre (Table 10). This financially optimal rotation would produce an estimated 3,155.86 cubic feet of pulpwood and 16.05 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 27.88 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 6). This optimal management regime will generate the maximum SEV of -$342.48 (Table 14), with a NPW of -$336.51 per acre (Table 10). This financially optimal rotation would produce an estimated 3,310.23 cubic feet of pulpwood and 12.82 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.98 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 76 (Table 6). This optimal management regime will generate the maximum SEV of -$408.72 (Table 14), with a NPW of -$407.16 per acre (Table 10). This financially optimal rotation would produce an estimated 3,318.89 cubic feet of pulpwood and 9.74 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.71 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 43 and 41 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 6). This optimal management regime will generate the maximum SEV of -$431.26 (Table 14), with a NPW of -$430.92 per acre (Table 10). This financially optimal rotation would produce an estimated 3,483.81 cubic feet of pulpwood and 8.55 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.46 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 75 (Table 6). This optimal management regime will generate the maximum SEV of -$441.59 (Table 14), with a NPW of -$441.54 per acre (Table 10). This financially optimal rotation would produce an estimated 3,252.62 cubic feet of pulpwood and 9.03 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.79 net tons of carbon per acre during one rotation (Table 2).

White oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 41 and 48 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 73 (Table 6). This optimal management regime will generate the maximum SEV of -$447.16 (Table 14), with a NPW of -$447.15 per acre (Table 10). This financially optimal rotation would produce an estimated 3,391.59 cubic feet of pulpwood and 7.68 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 22.45 net tons of carbon per acre during one rotation (Table 2).

<u>Central States-White oak - Timber Only Rotations (C = $37/ton)</u>

White oak, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 67 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $338.91 (Table 15), with a NPW of $303.08 per acre (Table 11). This means that $338.91 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $303.08 per acre for managing one rotation, or $338.91 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,924.39 cubic feet of pulpwood and 9.82 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.02 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White oak, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 69 and 84 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$144.94 (Table 15), with a NPW of -$143.23 per acre (Table 11). This financially optimal rotation would produce an estimated 2,973.17 cubic feet of pulpwood and 9.47 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 25.99 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 69 and 84 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$297.82 (Table 15), with a NPW of -$297.41 per acre (Table 11). This financially optimal rotation would produce an estimated 2,973.17 cubic feet of pulpwood and 9.47 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 25.99 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 69 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$364.16 (Table 15), with a NPW of -$364.10 per acre (Table 11). This financially optimal rotation would produce an estimated 3,021.03 cubic feet of pulpwood and 9.30 MBF of sawlogs

per acre from the thinning and final harvest (Table 19), and sequester 25.99 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 84 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$397.66 (Table 15), with a NPW of -$397.65 per acre (Table 11). This financially optimal rotation would produce an estimated 2,590.66 cubic feet of pulpwood and 8.78 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 23.05 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$416.46 (Table 15), with a NPW of -$416.46 per acre (Table 11). This financially optimal rotation would produce an estimated 2,548.44 cubic feet of pulpwood and 8.62 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 22.67 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 65 and 71 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $437.43 (Table 15), with a NPW of $391.19 per acre (Table 11). This financially optimal rotation would produce an estimated 3,232.67 cubic feet of pulpwood and 12.29 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 27.40 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 65 and 72 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$108.91 (Table 15), with a NPW of -$107.63 per acre (Table 11). This financially optimal rotation would produce an estimated 3,245.57 cubic feet of pulpwood and 12.11 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 27.42 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 68 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$275.98 (Table 15), with a NPW of -$275.60 per acre (Table 11). This financially optimal rotation would produce an estimated 3,204.96 cubic feet of pulpwood and 11.66 MBF of sawlogs

per acre from the thinning and final harvest (Table 19), and sequester 26.89 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 66 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$348.85 (Table 15), with a NPW of -$348.79 per acre (Table 11). This financially optimal rotation would produce an estimated 3,009.64 cubic feet of pulpwood and 11.42 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 25.76 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 72 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$386.19 (Table 15), with a NPW of -$386.18 per acre (Table 11). This financially optimal rotation would produce an estimated 3,041.94 cubic feet of pulpwood and 11.57 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 25.67 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 85 (with 20 percent of

basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$407.44 (Table 15), with a NPW of -$407.44 per acre (Table 11). This financially optimal rotation would produce an estimated 2,611.23 cubic feet of pulpwood and 10.59 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 22.61 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 62 and 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $549.79 (Table 15), with a NPW of $491.67 per acre (Table 11). This financially optimal rotation would produce an estimated 3,425.45 cubic feet of pulpwood and 15.81 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 28.79 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 62 and 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$75.80 (Table 15), with a NPW of -$74.90 per acre (Table 11). This financially optimal rotation would produce an estimated 3,425.45 cubic feet of pulpwood and 15.81 MBF of sawlogs per

acre from the thinning and final harvest (Table 19), and sequester 28.79 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 63 and 84 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$258.58 (Table 15), with a NPW of -$258.22 per acre (Table 11). This financially optimal rotation would produce an estimated 3,466.50 cubic feet of pulpwood and 15.60 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 28.82 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 63 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$337.31 (Table 15), with a NPW of -$337.25 per acre (Table 11). This financially optimal rotation would produce an estimated 3,348.88 cubic feet of pulpwood and 14.61 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 27.35 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 65 (with 20 percent of

basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of -$377.84 (Table 15), with a NPW of -$377.83 per acre (Table 11). This financially optimal rotation would produce an estimated 3,098.88 cubic feet of pulpwood and 14.20 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 25.98 net tons of carbon per acre during one rotation (Table 3).

White oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 78 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 7). This optimal management regime will generate the maximum SEV of -$401.07 (Table 15), with a NPW of -$401.07 per acre (Table 11). This financially optimal rotation would produce an estimated 2,849.55 cubic feet of pulpwood and 13.48 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 24.18 net tons of carbon per acre during one rotation (Table 3).

<u>Central States- White oak - Timber Only Rotations (C = $50/ton)</u>

White oak, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 69 and 84 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $578.55 (Table 16), with a NPW of $517.39 per acre (Table 12). This means that $578.55 is the

maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $517.39 per acre for managing one rotation, or $578.55 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,973.17 cubic feet of pulpwood and 9.47 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.99 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White oak, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 69 and 84 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$33.68 (Table 16), with a NPW of -$33.28 per acre (Table 12). This financially optimal rotation would produce an estimated 2,973.17 cubic feet of pulpwood and 9.47 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.99 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 69 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8).

This optimal management regime will generate the maximum SEV of -$237.69 (Table 16), with a NPW of -$237.36 per acre (Table 12). This financially optimal rotation would produce an estimated 3,021.03 cubic feet of pulpwood and 9.30 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.99 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 84 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$327.91 (Table 16), with a NPW of -$327.85 per acre (Table 12). This financially optimal rotation would produce an estimated 2,590.66 cubic feet of pulpwood and 8.78 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.05 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 84 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$373.79 (Table 16), with a NPW of -$373.78 per acre (Table 12). This financially optimal rotation would produce an estimated 2,590.66 cubic feet of pulpwood and 8.78 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 23.05 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 83 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$399.63 (Table 16), with a NPW of -$399.63 per acre (Table 12). This financially optimal rotation would produce an estimated 2,548.44 cubic feet of pulpwood and 8.62 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 22.67 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 65 and 71 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $693.90 (Table 16), with a NPW of $620.55 per acre (Table 12). This financially optimal rotation would produce an estimated 3,232.67 cubic feet of pulpwood and 12.29 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 27.40 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 68 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $13.13 (Table 16), with a NPW of $12.98 per acre (Table 12). This financially optimal rotation would produce an estimated 3,204.96 cubic feet of pulpwood and 11.66 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 26.89 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 66 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$208.36 (Table 16), with a NPW of -$208.07 per acre (Table 12). This financially optimal rotation would produce an estimated 3,009.64 cubic feet of pulpwood and 11.42 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.76 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 71 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$307.25 (Table 16), with a NPW of -$307.20 per acre (Table 12). This financially optimal rotation would produce an estimated 3,054.68 cubic feet of pulpwood and 11.61 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.86 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$358.29 (Table 16), with a NPW of -$358.29 per acre (Table 12). This financially optimal rotation would produce an estimated 2,611.23 cubic feet of pulpwood and 10.59 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 22.61 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$387.44 (Table 16), with a NPW of -$387.44 per acre (Table 12). This financially optimal rotation would produce an estimated 2,611.23 cubic feet of pulpwood and 10.59 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 22.61 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 62 and 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $820.77 (Table 16), with a NPW of $734.00 per acre (Table 12). This financially optimal rotation would

produce an estimated 3,425.45 cubic feet of pulpwood and 15.81 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 28.79 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 63 and 84 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $54.26 (Table 16), with a NPW of $53.62 per acre (Table 12). This financially optimal rotation would produce an estimated 3,466.50 cubic feet of pulpwood and 15.60 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 28.82 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 63 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$185.24 (Table 16), with a NPW of -$184.98 per acre (Table 12). This financially optimal rotation would produce an estimated 3,348.88 cubic feet of pulpwood and 14.61 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 27.35 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 65 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$291.71 (Table 16), with a NPW of -$291.66 per acre (Table 12). This financially optimal rotation would produce an estimated 3,346.15 cubic feet of pulpwood and 14.65 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 27.42 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 65 and 85 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$347.03 (Table 16), with a NPW of -$347.02 per acre (Table 12). This financially optimal rotation would produce an estimated 3,346.15 cubic feet of pulpwood and 14.65 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 27.42 net tons of carbon per acre during one rotation (Table 4).

White oak, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 80 (Table 8). This optimal management regime will generate the maximum SEV of -$378.84 (Table 16), with a NPW of -$378.84 per acre (Table 12). This financially optimal rotation would produce an estimated 3,015.71 cubic feet of pulpwood and 8.42 MBF of sawlogs per acre

from the thinning and final harvest (Table 20), and sequester 21.13 net tons of carbon per acre during one rotation (Table 4).

Species white oak Region South

Site indices 90, 100 and 110 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 9-in. inside bark top diameter for trees with a minimum of 12 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 11-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 20 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 25, 30 and 35% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.245225694 and 0.434027778, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Clark et al. (1986) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Yp = 0.15699(D^2H)^{0.93059}$$

$$Ys = 0.14218(D^2)^{0.95124}(H)^{0.93059}$$

where:

Yp = dry-weight (lbs.) of stemwood and bark of trees < 11.0 in. d.b.h

Ys = dry-weight (lbs.) of stemwood and bark of trees ≥ 11.0 in d.b.h

D = diameter at breast height (in.)

H = total height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 1.6% and 1.24% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $210/mbf (Scribner) (Timber Mart South, Inc. 2000-2005) and pulpwood price was assumed to be $16.44/cord (Timber Mart South, Inc. 2000-2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of white oak plantations in the South.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$60.00	Only once	Year 0	
Seedlings[b] (436 seedlings/ac)	$130.80	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).

[b]Data from Hans M. Williams, personal communication, Stephen F. Austin State University, December 19, 2006.

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Table 23. Total tons of carbon sequestered per acre for white oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	44.54	44.54	44.54	44.54	44.54	44.54
100	53.40	53.40	53.40	51.64	50.72	50.72
110	59.51	61.43	58.38	56.16	56.16	52.18

[1]Base age 50.

Table 24. Total tons of carbon sequestered per acre for white oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	46.17	46.17	46.17	46.17	45.61	45.61
100	53.49	55.59	53.49	53.13	53.13	50.72
110	65.98	65.21	63.43	57.20	57.20	55.49

[1]Base age 50.

Table 25. Total tons of carbon sequestered per acre for white oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	46.17	47.72	47.72	46.70	49.63	44.82
100	55.59	55.59	55.59	55.59	56.19	56.19
110	65.98	65.98	65.98	65.98	63.00	62.76

[1]Base age 50.

Table 26. Total tons of carbon sequestered per acre for white oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	46.17	47.72	47.72	49.63	49.63	44.95
100	55.59	55.59	55.59	56.19	56.19	57.84
110	65.98	65.98	65.98	65.12	65.96	65.96

[1]Base age 50.

Table 27. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	32-38-**60**[2] (35%)[3]	<32-38-**60>**[4](35%)	<32-38-**60>** (35%)	<32-38-**60>** (35%)	<32-38-**60>** (35%)	<32-38-**60>** (35%)
100	33-38-**60** (35%)	33-38-**60** (35%)	<33-38-**60>** (35%)	<31-36-**59**> (35%)	<31-36-**58**> (35%)	<31-36-**58**> (35%)
110	27-32-**60** (35%)	29-35-**60** (35%)	<27-33-**58**> (35%)	<27-33-**57**> (35%)	<27-33-**57**> (35%)	<27-32-**54**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 28. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	32-44-**60**[2] (35%)[3]	32-44-**60** (35%)	<32-44-**60**>[4] (35%)	<32-44-**60**> (35%)	<32-40-**60**> (35%)	<32-40-**60**> (35%)
100	33-38-**60** (35%)	35-46-**60** (35%)	<33-38-**60**> (35%)	<32-40-**59**> (35%)	<32-40-**59**> (35%)	<31-36-**58**> (35%)
110	36-45-**60** (30%)	32-42-**60** (30%)	<34-40-**59**> (35%)	<32-38-**56**> (35%)	<32-38-**56**> (35%)	<30-35-**55**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 29. Financially optimal thinning and final harvest schedules which maximize soil expectation value for white oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	32-44-**60**[2] (35%)[3]	37-48-**60** (35%)	37-48-**60** (35%)	<41-46-**60**>[4](35%)	<44-50-**60**> (25%)	<39-**60**> (25%)
100	35-46-**60** (35%)	35-46-**60** (35%)	35-46-**60** (35%)	<35-46-**60**> (35%)	<43-52-**60**> (35%)	<43-52-**60**> (35%)
110	36-45-**60** (30%)	36-45-**60** (30%)	36-45-**60** (30%)	36-45-**60** (30%)	<38-47-**58**> (30%)	<43-48-**58**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 30. Financially optimal thinning and final harvest schedules which maximize soil expectation value for White oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	32-44-**60**[2] (35%)[3]	37-48-**60** (35%)	37-48-**60** (35%)	<44-50-**60>**[4](25%)	<44-50-**60>** (25%)	<51-**60**> (25%)
100	35-46-**60** (35%)	35-46-**60** (35%)	35-46-**60** (35%)	43-52-**60** (35%)	<43-52-**60>** (35%)	<54-**60>** (35%)
110	36-45-**60** (30%)	36-45-**60** (30%)	36-45-**60** (30%)	40-46-**60** (25%)	55-**60** (35%)	<55-**60>** (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 31. Net present worth of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$878.30	-$65.37	-$294.70	-$353.54	-$369.42	-$373.81
100	$1,526.08	$94.26	-$252.85	-$341.55	-$365.11	-$372.08
110	$2,002.74	$211.41	-$219.14	-$328.79	-$360.32	-$369.81

[1]Base age 50.

Table 32. Net present worth of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$1,144.57	$92.36	-$195.27	-$286.59	-$321.45	-$338.00
100	$1,841.52	$285.76	-$129.56	-$257.32	-$304.86	-$326.73
110	$2,380.39	$439.76	-$73.73	-$228.76	-$287.62	-$314.77

[1]Base age 50.

Table 33. Net present worth of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$1,866.82	$525.60	$82.98	-$99.27	-$188.80	-$239.48
100	$2,726.06	$821.49	$212.37	-$25.69	-$139.04	-$202.30
110	$3,440.69	$1,082.71	$337.60	$49.55	-$86.68	-$162.84

[1]Base age 50.

Table 34. Net present worth of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,214.56	$740.35	$218.17	-$7.07	-$123.95	-$191.48
100	$3,152.78	$1,079.43	$377.26	$86.93	-$57.79	-$141.60
110	$3,951.20	$1,392.81	$536.80	$185.73	$12.04	-$88.50

[1]Base age 50.

Table 35. Soil expectation value of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$1,125.54	-$68.88	-$298.32	-$354.60	-$369.70	-$373.88
100	$1,960.88	$99.32	-$255.96	-$342.67	-$365.46	-$372.18
110	$2,573.36	$222.77	-$222.25	-$330.11	-$360.71	-$369.98

[1]Base age 50.

Table 36. Soil expectation value of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$1,470.68	$97.32	-$197.67	-$287.44	-$321.70	-$338.07
100	$2,366.20	$301.11	-$131.15	-$258.16	-$305.12	-$326.81
110	$3,058.60	$463.38	-$74.30	-$229.77	-$287.97	-$314.90

[1]Base age 50.

Table 37. Soil expectation value of the financially optimal thinning and final harvest schedules for white oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,398.71	$553.84	$84.00	-$99.56	-$188.94	-$239.53
100	$3,502.76	$865.62	$214.98	-$25.77	-$139.15	-$202.34
110	$4,421.00	$1,140.88	$341.74	$49.70	-$86.76	-$162.88

[1]Base age 50.

Table 38. Soil expectation value of the financially optimal thinning and final harvest schedules for White oak plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,845.53	$780.12	$220.85	-$7.09	-$124.05	-$191.52
100	$4,051.07	$1,137.43	$381.90	$87.19	-$57.84	-$141.63
110	$5,076.97	$1,467.64	$543.40	$186.28	$12.05	-$88.52

[1]Base age 50.

Table 39. Volume removed from the financially optimal schedules for white oak plantations by soil productivity and real alternative rates of return in the southern United States). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	32-38-**60**[3] (35%)[4]	732.11	0	823.81	0	1936.01	9.52	3,491.93	9.52
	5.0%	32-38-**60** (35%)	732.11	0	823.81	0	1936.01	9.52	3,491.93	9.52
	7.5%	32-38-**60** (35%)	732.11	0	823.81	0	1936.01	9.52	3,491.93	9.52
	10.0%	32-38-**60** (35%)	732.11	0	823.81	0	1936.01	9.52	3,491.93	9.52
	12.5%	32-38-**60** (35%)	732.11	0	823.81	0	1936.01	9.52	3,491.93	9.52
	15.0%	32-38-**60** (35%)	732.11	0	823.81	0	1936.01	9.52	3,491.93	9.52
100	2.5%	33-38-**60** (35%)	1,078.17	0	998.84	0	1,117.80	15.40	3,194.81	15.40
	5.0%	33-38-**60** (35%)	1,078.17	0	998.84	0	1,117.80	15.40	3,194.81	15.40
	7.5%	33-38-**60** (35%)	1,078.17	0	998.84	0	1,117.80	15.40	3,194.81	15.40
	10.0%	31-36-**59** (35%)	951.47	0	912.11	0	1,517.67	13.67	3,381.25	13.67
	12.5%	31-36-**58** (35%)	951.47	0	912.11	0	1,705.08	12.35	3,568.66	12.35
	15.0%	31-36-**58** (35%)	951.47	0	912.11	0	1,705.08	12.35	3,568.66	12.35
110	2.5%	27-32-**60** (35%)	726.59	0	870.84	0	975.23	20.00	2,572.66	20.00
	5.0%	29-35-**60** (35%)	979.80	0	1,045.00	0	974.84	19.68	2,999.64	19.68
	7.5%	27-36-**58** (35%)	726.59	0	1,119.10	0	1,023.26	18.08	2,868.95	18.08
	10.0%	27-33-**57** (35%)	726.59	0	930.03	0	1,207.56	16.88	2,864.18	16.88
	12.5%	27-33-**57** (35%)	726.59	0	930.03	0	1,207.56	16.88	2,864.18	16.88
	15.0%	27-32-**54** (35%)	726.59	0	870.84	0	2,111.72	11.50	3,709.15	11.50

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 40. Volume removed from the financially optimal schedules for White oak plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	32-44-**60**[3] (35%)[4]	732.11	0	1,126.66	0	1,880.55	9.40	3,739.32	9.40
	5.0%	32-44-**60** (35%)	732.11	0	1,126.66	0	1,880.55	9.40	3,739.32	9.40
	7.5%	32-44-**60** (35%)	732.11	0	1,126.66	0	1,880.55	9.40	3,739.32	9.40
	10.0%	32-44-**60** (35%)	732.11	0	1,126.66	0	1,880.55	9.40	3,739.32	9.40
	12.5%	34-40-**60** (35%)	922.36	0	915.50	0	2,073.77	8.70	3,911.63	8.70
	15.0%	34-40-**60** (35%)	922.36	0	915.50	0	2,073.77	8.70	3,911.63	8.70
100	2.5%	33-38-**60** (35%)	1,078.17	0	998.84	0	1,117.80	15.40	3,194.81	15.40
	5.0%	35-46-**60** (35%)	1,192.87	0	1,435.21	0	960.96	15.09	3,589.04	15.09
	7.5%	33-38-**60** (35%)	1,078.17	0	998.84	0	1,117.80	15.40	3,194.81	15.40
	10.0%	32-40-**59** (35%)	1,020.85	0	1,130.80	0	1,322.70	14.07	3,474.35	14.07
	12.5%	32-40-**59** (35%)	1,020.85	0	1,130.80	0	1,322.70	14.07	3,474.35	14.07
	15.0%	31-36-**58** (35%)	951.47	0	912.11	0	1,705.08	12.35	3,568.66	12.35
110	2.5%	36-45-**60** (30%)	1,259.68	0	1,428.05	0	1,096.84	19.26	3,784.57	19.26
	5.0%	32-42-**60** (30%)	1,038.94	0	1,327.66	0	1,263.73	19.34	3,630.33	19.34
	7.5%	34-40-**59** (30%)	1,151.98	0	1,168.75	0	1,264.48	18.63	3,585.21	18.63
	10.0%	32-38-**56** (35%)	1,217.74	0	1,186.71	0	1,176.15	15.25	3,580.60	15.25
	12.5%	32-38-**56** (35%)	1,217.74	0	1,186.71	0	1,176.15	15.25	3,580.60	15.25
	15.0%	30-35-**55** (35%)	1,091.31	0	1,035.06	0	1,845.82	12.76	3,972.19	12.76

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 41. Volume removed from the financially optimal schedules for White oak plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	32-44-**60**[3] (35%)[4]	732.11	0	1,126.66	0	1,880.55	9.40	3,739.32	9.40
	5.0%	37-48-**60** (35%)	1,085.03	0	1,285.52	0	1,900.98	8.46	4,271.53	8.46
	7.5%	37-48-**60** (35%)	1,085.03	0	1,285.52	0	1,900.98	8.46	4,271.53	8.46
	10.0%	41-46-**60** (35%)	1288.70	0	1,117.71	0	1,771.30	8.36	4,177.71	8.36
	12.5%	44-50-**60** (25%)	1024.93	0	1,024.83	0	3,016.19	6.44	5,065.95	6.44
	15.0%	39-**60** (25%)	839.10	0	-[5]	-	4,216.06	5.52	5,055.16	5.52
100	2.5%	35-46-**60** (35%)	1192.87	0	1,435.21	0	960.96	15.09	3,589.04	15.09
	5.0%	35-46-**60** (35%)	1192.87	0	1,435.21	0	960.96	15.09	3,589.04	15.09
	7.5%	35-46-**60** (35%)	1192.87	0	1,435.21	0	960.96	15.09	3,589.04	15.09
	10.0%	35-46-**60** (35%)	1192.87	0	1,435.21	0	960.96	15.09	3,589.04	15.09
	12.5%	43-52-**60** (35%)	1655.28	0	1,636.93	0	1,145.76	12.14	4,437.97	12.14
	15.0%	43-52-**60** (35%)	1655.28	0	1,636.93	0	1,145.76	12.14	4,437.97	12.14
110	2.5%	36-45-**60** (30%)	1259.68	0	1,428.05	0	1,096.84	19.26	3,784.57	19.26
	5.0%	36-45-**60** (30%)	1259.68	0	1,428.05	0	1,096.84	19.26	3,784.57	19.26
	7.5%	36-45-**60** (30%)	1259.68	0	1,428.05	0	1,096.84	19.26	3,784.57	19.26
	10.0%	36-45-**60** (30%)	1259.68	0	1,428.05	0	1,096.84	19.26	3,784.57	19.26
	12.5%	38-47-**58** (30%)	1371.35	0	1,497.17	0	1,330.13	16.03	4,198.65	16.03
	15.0%	43-48-**58** (30%)	1647.72	0	1,479.67	0	1,387.88	14.68	4,515.27	14.68

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 42. Volume removed from the financially optimal schedules for white oak plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.5%	32-44-**60**[3] (35%)[4]	732.11	0	1,126.66	0	1,880.55	9.40	3,739.32	9.40
	5.0%	37-48-**60** (35%)	1,085.03	0	1,285.52	0	1,900.98	8.46	4,271.53	8.46
	7.5%	37-48-**60** (35%)	1,085.03	0	1,285.52	0	1,900.98	8.46	4,271.53	8.46
	10.0%	44-50-**60** (25%)	1,024.93	0	1,024.83	0	3,016.19	6.44	5,065.95	6.44
	12.5%	44-50-**60** (25%)	1,024.93	0	1,024.83	0	3,016.19	6.44	5,065.95	6.44
	15.0%	51-**60** (25%)	1,278.15	0	-[5]	-	4,195.82	3.97	5,473.97	3.97
100	2.5%	35-46-**60** (35%)	1,192.87	0	1,435.21	0	960.96	15.09	3,589.04	15.09
	5.0%	35-46-**60** (35%)	1,192.87	0	1,435.21	0	960.96	15.09	3,589.04	15.09
	7.5%	35-46-**60** (35%)	1,192.87	0	1,435.21	0	960.96	15.09	3,589.04	15.09
	10.0%	43-52-**60** (35%)	1,655.28	0	1,636.93	0	1,145.76	12.14	4,437.97	12.14
	12.5%	43-52-**60** (35%)	1,655.28	0	1,636.93	0	1,145.76	12.14	4,437.97	12.14
	15.0%	54-**60** (35%)	2,297.63	0	-	-	3,392.24	8.13	5,689.87	8.13
110	2.5%	36-45-**60** (30%)	1,259.68	0	1,428.05	0	1,096.84	19.26	3,784.57	19.26
	5.0%	36-45-**60** (30%)	1,259.68	0	1,428.05	0	1,096.84	19.26	3,784.57	19.26
	7.5%	36-45-**60** (30%)	1,259.68	0	1,428.05	0	1,096.84	19.26	3,784.57	19.26
	10.0%	40-46-**60** (25%)	1,228.24	0	1,224.69	-	1,571.93	17.90	4,024.86	17.90
	12.5%	55-**60** (35%)	2,717.89	0	-	-	2,368.22	14.31	5,086.11	14.31
	15.0%	55-**60** (35%)	2,717.89	0	-	-	2,368.22	14.31	5,086.11	14.31

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 43. Financially optimal thinning and final harvest schedules for white oak plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	90	32-38-**60**[2] (35%)[3]	32-44-**60** (35%)	0%	32-44-**60** (35%)	0%	32-44-**60** (35%)	0%
	100	33-38-**60** (35%)	33-38-**60** (35%)	0%	35-46-**60** (35%)	0%	35-46-**60** (35%)	0%
	110	27-32-**60** (35%)	36-45-**60** (30%)	0%	36-45-**60** (30%)	0%	36-45-**60** (30%)	0%
5.00%	90	<32-38-**60**>[4](35%)	32-44-**60** (35%)	0%	37-48-**60** (35%)	0%	37-48-**60** (35%)	0%
	100	33-38-**60** (35%)	35-46-**60** (35%)	0%	35-46-**60** (35%)	0%	35-46-**60** (35%)	0%
	110	29-35-**60** (35%)	32-42-**60** (30%)	0%	36-45-**60** (30%)	0%	36-45-**60** (30%)	0%
7.50%	90	<32-38-**60**> (35%)	<32-44-**60**> (35%)	0%	37-48-**60** (35%)	0%	37-48-**60** (35%)	0%
	100	<33-38-**60**> (35%)	<33-38-**60**> (35%)	0%	35-46-**60** (35%)	0%	35-46-**60** (35%)	0%
	110	<27-33-**58**> (35%)	<34-40-**59**> (35%)	2%	36-45-**60** (30%)	3%	36-45-**60** (30%)	3%
10.00%	90	<32-38-**60**> (35%)	<32-44-**60**> (35%)	0%	<41-46-**60**> (35%)	0%	<44-50-**60**> (25%)	0%
	100	<31-36-**59**> (35%)	<32-40-**59**> (35%)	0%	<35-46-**60**> (35%)	2%	43-52-**60** (35%)	2%
	110	<27-33-**57**> (35%)	<32-38-**56**> (35%)	-2%	36-45-**60** (30%)	5%	40-46-**60** (25%)	5%
12.50%	90	<32-38-**60**> (35%)	<32-40-**60**> (35%)	0%	<44-50-**60**> (25%)	0%	<44-50-**60**> (25%)	0%
	100	<31-36-**58**> (35%)	<32-40-**59**> (35%)	2%	<43-52-**60**> (35%)	3%	<43-52-**60**> (35%)	3%
	110	<27-33-**57**> (35%)	<32-38-**56**> (35%)	-2%	<38-47-**58**> (30%)	2%	55-**60** (35%)	5%
15.00%	90	<32-38-**60**> (35%)	<32-40-**60**> (35%)	0%	<39-**60**> (25%)	0%	<51-**60**> (25%)	0%
	100	<31-36-**58**> (35%)	<31-36-**58**> (35%)	0%	<43-52-**60**> (35%)	3%	<54-**60**> (35%)	3%
	110	<27-32-**54**> (35%)	<30-35-**55**> (35%)	2%	<43-48-**58**> (30%)	7%	<55-**60**> (35%)	11%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3]Number in parentheses indicates the percentage of basal area removed during thinning

[4]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 44. The soil expectation value ($/acre) of the financially optimal rotations for white oak plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	90	1,125.54	1,470.68	31%	2,398.71	113%	2,845.53	153%
	100	1,960.88	2,366.20	21%	3,502.76	79%	4,051.07	107%
	110	2,573.36	3,058.60	19%	4,421.00	72%	5,076.97	97%
5.00%	90	-68.88	97.32		553.84		780.12	
	100	99.32	301.11	203%	865.62	772%	1,137.43	1045%
	110	222.77	463.38	108%	1,140.88	412%	1,467.64	559%
7.50%	90	-298.32	-197.67		84.00		220.85	
	100	-255.96	-131.15		214.98		381.90	
	110	-222.25	-74.30		341.74		543.40	
10.00%	90	-354.60	-287.44		-99.56		-7.09	
	100	-342.67	-258.16		-25.77		87.19	
	110	-330.11	-229.77		49.70		186.28	
12.50%	90	-369.70	-321.70		-188.94		-124.05	
	100	-365.46	-305.12		-139.15		-57.84	
	110	-360.71	-287.97		-86.76		12.05	
15.00%	90	-373.88	-338.07		-239.53		-191.52	
	100	-372.18	-326.81		-202.34		-141.63	
	110	-369.98	-314.90		-162.88		-88.52	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

<u>Southern- White oak - Timber Only Rotations (C = $0/ton)</u>

White oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 32 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 27). This optimal management regime will generate the maximum SEV of $1,125.54 (Table 35), with a NPW of $878.30 per acre (Table 31). This means that $1,125.54 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $878.30 per acre for managing one rotation, or $1,125.54 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 3,491.93 cubic feet of pulpwood and 9.52 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 44.54 net tons of carbon per acre during one rotation (Table 23). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 32 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 27). This optimal management regime will generate the maximum SEV of -$68.88 (Table 35), with a NPW of -$65.37 per acre (Table 31). This financially optimal rotation could produce

an estimated 3,491.93 cubic feet of pulpwood and 9.52 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 44.54 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 32 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 27). This optimal management regime will generate the maximum SEV of -$298.32 (Table 35), with a NPW of -$294.70 per acre (Table 31). This financially optimal rotation could produce an estimated 3,491.93 cubic feet of pulpwood and 9.52 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 44.54 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 32 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 27). This optimal management regime will generate the maximum SEV of -$354.60 (Table 35), with a NPW of -$353.54 per acre (Table 31). This financially optimal rotation could produce an estimated 3,491.93 cubic feet of pulpwood and 9.52 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 44.54 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 32 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 27). This optimal management regime will generate the maximum SEV of -\$369.70 (Table 35), with a NPW of -\$369.42 per acre (Table 31). This financially optimal rotation could produce an estimated 3,491.93 cubic feet of pulpwood and 9.52 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 44.54 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = \$0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 32 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 27). This optimal management regime will generate the maximum SEV of -\$373.88 (Table 35), with a NPW of -\$373.81 per acre (Table 31). This financially optimal rotation could produce an estimated 3,491.93 cubic feet of pulpwood and 9.52 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 44.54 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = \$0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 27). This optimal management regime will generate the maximum SEV of \$1,960.88 (Table 35), with a NPW of \$1,526.08 per acre (Table 31). This financially optimal rotation could

produce an estimated 3,194.81 cubic feet of pulpwood and 15.40 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 53.40 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 27). This optimal management regime will generate the maximum SEV of $99.32 (Table 35), with a NPW of $94.26 per acre (Table 31). This financially optimal rotation could produce an estimated 3,194.81 cubic feet of pulpwood and 15.40 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 53.40 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 27). This optimal management regime will generate the maximum SEV of -$255.96 (Table 35), with a NPW of -$252.85 per acre (Table 31). This financially optimal rotation could produce an estimated 3,194.81 cubic feet of pulpwood and 15.40 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 53.40 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 31 and 36 (with 35 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 27). This optimal management regime will generate the maximum SEV of -$342.67 (Table 35), with a NPW of -$341.55 per acre (Table 31). This financially optimal rotation could produce an estimated 3,381.25 cubic feet of pulpwood and 13.67 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 51.64 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 31 and 36 (with 35 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 27). This optimal management regime will generate the maximum SEV of -$365.46 (Table 35), with a NPW of -$365.11 per acre (Table 31). This financially optimal rotation could produce an estimated 3,568.66 cubic feet of pulpwood and 12.35 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 50.72 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 31 and 36 (with 35 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 27). This optimal management regime will generate the maximum SEV of -$372.18 (Table 35), with a NPW of -$372.08 per acre (Table 31). This financially optimal rotation could

produce an estimated 3,568.66 cubic feet of pulpwood and 12.35 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 50.72 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 27 and 32 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 27). This optimal management regime will generate the maximum SEV of $2,573.36 (Table 35), with a NPW of $2,002.74 per acre (Table 31). This financially optimal rotation could produce an estimated 2,572.66 cubic feet of pulpwood and 20.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 59.51 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 29 and 35 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 27). This optimal management regime will generate the maximum SEV of $222.77 (Table 35), with a NPW of $211.41 per acre (Table 31). This financially optimal rotation could produce an estimated 2,999.64 cubic feet of pulpwood and 19.68 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 61.43 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 27 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 27). This optimal management regime will generate the maximum SEV of -$222.25 (Table 35), with a NPW of -$219.14 per acre (Table 31). This financially optimal rotation could produce an estimated 2,868.95 cubic feet of pulpwood and 18.08 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 58.38 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 27 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 27). This optimal management regime will generate the maximum SEV of -$330.11 (Table 35), with a NPW of -$328.79 per acre (Table 31). This financially optimal rotation could produce an estimated 2,864.18 cubic feet of pulpwood and 16.88 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 56.16 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 27 and 33 (with 35 percent of basal area removed) and a final harvest at stand age 57 are conducted (Table 27). This optimal management regime will generate the maximum SEV of -$360.71 (Table 35), with a NPW of -$360.32 per acre (Table 31). This financially optimal rotation could

produce an estimated 2,864.18 cubic feet of pulpwood and 16.88 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 56.16 net tons of carbon per acre during one rotation (Table 23).

White oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 27 and 22 (with 35 percent of basal area removed) and a final harvest at stand age 54 are conducted (Table 27). This optimal management regime will generate the maximum SEV of -$369.98 (Table 35), with a NPW of -$369.81 per acre (Table 31). This financially optimal rotation could produce an estimated 3,709.15 cubic feet of pulpwood and 11.50 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 52.18 net tons of carbon per acre during one rotation (Table 23).

Southern- White oak - Timber + Carbon Rotations (C = $10/ton)

White oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 32 and 44 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 28). This optimal management regime will generate the maximum SEV of $1,470.68 (Table 36), with a NPW of $1,144.57 per acre (Table 32). This means that $1,470.68 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on

every dollar invested plus $1,144.57 per acre for managing one rotation, or $1,470.68 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 3,739.32 cubic feet of pulpwood and 9.40 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 46.17 net tons of carbon per acre during one rotation (Table 24). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 32 and 44 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 28). This optimal management regime will generate the maximum SEV of $97.32 (Table 36), with a NPW of $92.36 per acre (Table 32). This financially optimal rotation could produce an estimated 3,739.32 cubic feet of pulpwood and 9.40 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 46.17 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 32 and 44 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 28). This optimal management regime will generate the maximum SEV of -$197.67 (Table 36), with a NPW of -$195.27 per acre (Table 32). This financially optimal rotation could produce an estimated 3,739.32 cubic feet of pulpwood and 9.40 MBF of sawlogs per acre

from the thinning and final harvest (Table 40), and sequester 46.17 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 32 and 44 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 28). This optimal management regime will generate the maximum SEV of -$287.44 (Table 36), with a NPW of -$286.59 per acre (Table 32). This financially optimal rotation could produce an estimated 3,739.32 cubic feet of pulpwood and 9.40 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 46.17 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 32 and 40 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 28). This optimal management regime will generate the maximum SEV of -$321.70 (Table 36), with a NPW of -$321.45 per acre (Table 32). This financially optimal rotation could produce an estimated 3,911.63 cubic feet of pulpwood and 8.70 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 45.61 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 32 and 40 (with 35 percent of

basal area removed) and a final harvest at stand age 60 are conducted (Table 28). This optimal management regime will generate the maximum SEV of -$338.07 (Table 36), with a NPW of -$338.00 per acre (Table 32). This financially optimal rotation could produce an estimated 3,911.63 cubic feet of pulpwood and 8.70 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 45.61 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 28). This optimal management regime will generate the maximum SEV of $2,366.20 (Table 36), with a NPW of $1,841.52 per acre (Table 32). This financially optimal rotation could produce an estimated 3,194.81 cubic feet of pulpwood and 15.40 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 53.49 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 35 and 46 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 28). This optimal management regime will generate the maximum SEV of $301.11 (Table 36), with a NPW of $285.76 per acre (Table 32). This financially optimal rotation could produce an estimated 3,589.04 cubic feet of pulpwood and 15.09 MBF of sawlogs per

acre from the thinning and final harvest (Table 40), and sequester 55.59 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 33 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 28). This optimal management regime will generate the maximum SEV of -$131.15 (Table 36), with a NPW of -$129.56 per acre (Table 32). This financially optimal rotation could produce an estimated 3,194.81 cubic feet of pulpwood and 15.40 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 53.49 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 32 and 40 (with 35 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 28). This optimal management regime will generate the maximum SEV of -$258.16 (Table 36), with a NPW of -$257.32 per acre (Table 32). This financially optimal rotation could produce an estimated 3,474.35 cubic feet of pulpwood and 14.07 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 53.13 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 32 and 40 (with 35 percent of

basal area removed) and a final harvest at stand age 59 are conducted (Table 28). This optimal management regime will generate the maximum SEV of -$305.12 (Table 36), with a NPW of -$304.86 per acre (Table 32). This financially optimal rotation could produce an estimated 3,474.35 cubic feet of pulpwood and 14.07 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 53.13 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 31 and 36 (with 35 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 28). This optimal management regime will generate the maximum SEV of -$326.81 (Table 36), with a NPW of -$326.73 per acre (Table 32). This financially optimal rotation could produce an estimated 3,568.66 cubic feet of pulpwood and 12.35 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 50.72 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 28). This optimal management regime will generate the maximum SEV of $3,058.60 (Table 36), with a NPW of $2,380.39 per acre (Table 32). This financially optimal rotation could produce an estimated 3,784.57 cubic feet of pulpwood and 19.26 MBF of sawlogs per

acre from the thinning and final harvest (Table 40), and sequester 65.98 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 32 and 42 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 28). This optimal management regime will generate the maximum SEV of $463.38 (Table 36), with a NPW of $439.76 per acre (Table 32). This financially optimal rotation could produce an estimated 3,630.33 cubic feet of pulpwood and 19.34 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 65.21 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 34 and 40 (with 35 percent of basal area removed) and a final harvest at stand age 59 are conducted (Table 28). This optimal management regime will generate the maximum SEV of -$74.30 (Table 36), with a NPW of -$73.73 per acre (Table 32). This financially optimal rotation could produce an estimated 3,585.21 cubic feet of pulpwood and 18.63 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 63.43 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 32 and 38 (with 35 percent of

basal area removed) and a final harvest at stand age 56 are conducted (Table 28). This optimal management regime will generate the maximum SEV of -$229.77 (Table 36), with a NPW of -$228.76 per acre (Table 32). This financially optimal rotation could produce an estimated 3,580.60 cubic feet of pulpwood and 15.25 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 57.20 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 32 and 38 (with 35 percent of basal area removed) and a final harvest at stand age 56 are conducted (Table 28). This optimal management regime will generate the maximum SEV of -$287.97 (Table 36), with a NPW of -$287.62 per acre (Table 32). This financially optimal rotation could produce an estimated 3,580.60 cubic feet of pulpwood and 15.25 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 57.20 net tons of carbon per acre during one rotation (Table 24).

White oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 30 and 35 (with 35 percent of basal area removed) and a final harvest at stand age 55 are conducted (Table 28). This optimal management regime will generate the maximum SEV of -$314.90 (Table 36), with a NPW of -$314.77 per acre (Table 32). This financially optimal rotation could produce an estimated 3,972.19 cubic feet of pulpwood and 12.76 MBF of sawlogs per

acre from the thinning and final harvest (Table 40), and sequester 55.49 net tons of carbon per acre during one rotation (Table 24).

<u>Southern- White oak - Timber + Carbon Rotations (C = $37/ton)</u>

White oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 32 and 44 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of $2,398.71 (Table 37), with a NPW of $1,866.82 per acre (Table 33). This means that $2,398.71 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,866.82 per acre for managing one rotation, or $2,398.71 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 3,739.32 cubic feet of pulpwood and 9.40 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 46.17 net tons of carbon per acre during one rotation (Table 25). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 37 and 48 (with 35 percent of

basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of $553.84 (Table 37), with a NPW of $525.60 per acre (Table 33). This financially optimal rotation could produce an estimated 4,271.63 cubic feet of pulpwood and 8.46 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 47.72 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 37 and 48 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of $84.00 (Table 37), with a NPW of $82.98 per acre (Table 33). This financially optimal rotation could produce an estimated 4,271.63 cubic feet of pulpwood and 8.46 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 47.72 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 41 and 46 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of -$99.56 (Table 37), with a NPW of -$99.27 per acre (Table 33). This financially optimal rotation could produce an estimated 4,177.71 cubic feet of pulpwood and 8.36 MBF of sawlogs per acre from the

thinning and final harvest (Table 41), and sequester 46.70 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 44 and 50 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of -$188.94 (Table 37), with a NPW of -$188.80 per acre (Table 33). This financially optimal rotation could produce an estimated 5,065.95 cubic feet of pulpwood and 6.44 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 49.63 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 39 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of -$239.53 (Table 37), with a NPW of -$239.48 per acre (Table 33). This financially optimal rotation could produce an estimated 5,055.16 cubic feet of pulpwood and 5.52 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 44.82 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 35 and 46 (with 35 percent of

basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of $3,502.76 (Table 37), with a NPW of $2,726.06 per acre (Table 33). This financially optimal rotation could produce an estimated 3,589.04 cubic feet of pulpwood and 15.09 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 55.59 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 35 and 46 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of $865.62 (Table 37), with a NPW of $821.49 per acre (Table 33). This financially optimal rotation could produce an estimated 3,589.04 cubic feet of pulpwood and 15.09 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 55.59 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 35 and 46 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of $214.98 (Table 37), with a NPW of $212.37 per acre (Table 33). This financially optimal rotation could produce an estimated 3,589.04 cubic feet of pulpwood and 15.09 MBF of sawlogs per

acre from the thinning and final harvest (Table 41), and sequester 55.59 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 35 and 46 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of -$25.77 (Table 37), with a NPW of -$25.69 per acre (Table 33). This financially optimal rotation could produce an estimated 3,589.04 cubic feet of pulpwood and 15.09 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 55.59 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 43 and 52 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of -$139.15 (Table 37), with a NPW of -$139.04 per acre (Table 33). This financially optimal rotation could produce an estimated 4,437.97 cubic feet of pulpwood and 12.14 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 56.19 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 43 and 52 (with 35 percent of

basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of -$202.34 (Table 37), with a NPW of -$202.30 per acre (Table 33). This financially optimal rotation could produce an estimated 4,437.97 cubic feet of pulpwood and 12.14 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 56.19 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of $4,421.00 (Table 37), with a NPW of $3,440.69 per acre (Table 33). This financially optimal rotation could produce an estimated 3,784.57 cubic feet of pulpwood and 19.26 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 65.98 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of $1,140.88 (Table 37), with a NPW of $1,082.71 per acre (Table 33). This financially optimal rotation could produce an estimated 3,784.57 cubic feet of pulpwood and 19.26 MBF of sawlogs per

acre from the thinning and final harvest (Table 41), and sequester 65.98 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of $341.74 (Table 37), with a NPW of $337.60 per acre (Table 33). This financially optimal rotation could produce an estimated 3,784.57 cubic feet of pulpwood and 19.26 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 65.98 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 29). This optimal management regime will generate the maximum SEV of $49.70 (Table 37), with a NPW of $49.55 per acre (Table 33). This financially optimal rotation could produce an estimated 3,784.57 cubic feet of pulpwood and 19.26 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 65.98 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 38 and 47 (with 30 percent of

basal area removed) and a final harvest at stand age 58 are conducted (Table 29). This optimal management regime will generate the maximum SEV of -$86.76 (Table 37), with a NPW of -$86.68 per acre (Table 33). This financially optimal rotation could produce an estimated 4,198.65 cubic feet of pulpwood and 16.03 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 63.00 net tons of carbon per acre during one rotation (Table 25).

White oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings at stand ages 43 and 48 (with 30 percent of basal area removed) and a final harvest at stand age 58 are conducted (Table 29). This optimal management regime will generate the maximum SEV of -$162.88 (Table 37), with a NPW of -$162.84 per acre (Table 33). This financially optimal rotation could produce an estimated 4,515.27 cubic feet of pulpwood and 14.68 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 62.76 net tons of carbon per acre during one rotation (Table 25).

Southern- White oak - Timber + Carbon Rotations (C = $50/ton)

White oak, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 32 and 44 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of $2,845.53 (Table 38), with a NPW of $2,214.56 per acre (Table 34). This means that $2,845.53 is the

maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 70 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,214.56 per acre for managing one rotation, or $2,845.53 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation could produce an estimated 3,739.32 cubic feet of pulpwood and 9.40 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 46.17 net tons of carbon per acre during one rotation (Table 26). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

White oak, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 37 and 48 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of $780.12 (Table 38), with a NPW of $740.35 per acre (Table 34). This financially optimal rotation could produce an estimated 4,271.53 cubic feet of pulpwood and 8.76 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 47.72 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 37 and 48 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This

optimal management regime will generate the maximum SEV of $220.85 (Table 38), with a NPW of $218.17 per acre (Table 34). This financially optimal rotation could produce an estimated 4,271.53 cubic feet of pulpwood and 8.76 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 42.72 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 44 and 50 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of -$7.09 (Table 38), with a NPW of -$7.07 per acre (Table 34). This financially optimal rotation could produce an estimated 5,065.95 cubic feet of pulpwood and 6.44 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 49.63 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 44 and 50 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of -$124.05 (Table 38), with a NPW of -$123.95 per acre (Table 34). This financially optimal rotation could produce an estimated 5,065.95 cubic feet of pulpwood and 6.44 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 49.63 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 51 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of -$191.52 (Table 38), with a NPW of -$191.48 per acre (Table 34). This financially optimal rotation could produce an estimated 5,473.97 cubic feet of pulpwood and 3.97 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 44.95 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 35 and 46 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of $4,051.07 (Table 38), with a NPW of $3,152.78 per acre (Table 34). This financially optimal rotation could produce an estimated 3,589.04 cubic feet of pulpwood and 15.09 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 55.59 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 35 and 46 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of $1,137.43 (Table 38),

with a NPW of $1,079.43 per acre (Table 34). This financially optimal rotation could produce an estimated 3,589.04 cubic feet of pulpwood and 15.09 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 55.59 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 35 and 46 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of $381.90 (Table 38), with a NPW of $377.26 per acre (Table 34). This financially optimal rotation could produce an estimated 3,589.04 cubic feet of pulpwood and 15.09 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 55.59 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 43 and 52 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of $87.19 (Table 38), with a NPW of $86.93 per acre (Table 34). This financially optimal rotation could produce an estimated 4,437.97 cubic feet of pulpwood and 12.14 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 56.19 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings at stand ages 43 and 52 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of -$57.84 (Table 38), with a NPW of -$57.79 per acre (Table 34). This financially optimal rotation could produce an estimated 4,437.97 cubic feet of pulpwood and 12.14 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 56.19 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 54 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of -$141.63 (Table 38), with a NPW of -$141.60 per acre (Table 34). This financially optimal rotation could produce an estimated 5,689.87 cubic feet of pulpwood and 8.13 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 57.84 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of $5,076.97 (Table 38), with a NPW of $3,951.20 per acre (Table 34). This financially optimal rotation could

produce an estimated 3,784.57 cubic feet of pulpwood and 19.26 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 65.98 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of $1,467.64 (Table 38), with a NPW of $1,392.81 per acre (Table 34). This financially optimal rotation could produce an estimated 3,784.57 cubic feet of pulpwood and 19.26 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 65.98 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings at stand ages 36 and 45 (with 30 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of $543.40 (Table 38), with a NPW of $536.80 per acre (Table 34). This financially optimal rotation could produce an estimated 3,784.57 cubic feet of pulpwood and 19.26 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 65.98 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings at stand ages 40 and 46 (with 25 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of $186.28 (Table 38), with a NPW of $185.73 per acre (Table 34). This financially optimal rotation could produce an estimated 4,024.86 cubic feet of pulpwood and 17.90 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 65.12 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning at stand age 55 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of $12.05 (Table 38), with a NPW of $12.04 per acre (Table 34). This financially optimal rotation could produce an estimated 5,086.11 cubic feet of pulpwood and 14.31 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 65.96 net tons of carbon per acre during one rotation (Table 26).

White oak, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning at stand age 55 (with 35 percent of basal area removed) and a final harvest at stand age 60 are conducted (Table 30). This optimal management regime will generate the maximum SEV of -$88.52 (Table 38), with a NPW of -$88.50 per acre (Table 34). This financially optimal rotation could produce an

estimated 5,086.11 cubic feet of pulpwood and 14.13 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 65.96 net tons of carbon per acre during one rotation (Table 26).

Yellow birch (*Betula alleghaniensis*)

Betulaceae – Birch family

Yellow birch is one of the largest and most desirable native birches in North America. An immediate identifier of yellow birch is the mildly aromatic wintergreen smell of the inner bark and the yellowish-bronze exfoliating bark. This slow-growing long-live tree is generally found with such hardwoods as sugar maple, beech, basswood and white ash, and with such conifers as balsam fir, hemlock, white spruce and white pine (Domtar Inc. http://www.domtar.com/arbre/english/p_boulj.htm. April 24, 2006). It adapts to various sites, but prefers the moist well-drained soils of the uplands and mountain ravines. (USDA Forest Service, http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/alleghaniensis%20.htm. April 24, 2006).

The main distribution of yellow birch is northern, extending from Newfoundland, to northern Minnesota and northeastern Iowa; south through Wisconsin and Michigan to Pennsylvania; and in the Appalachian Mountains to northern Georgia. It is widely distributed in Quebec, Ontario, Maine, Upper Michigan, New York, and New Brunswick. About 50 percent of the lumber market under the name of yellow birch comes from Quebec (USDA Forest Service, http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/alleghaniensis%20.htm. April 24, 2006) (Fig.1).

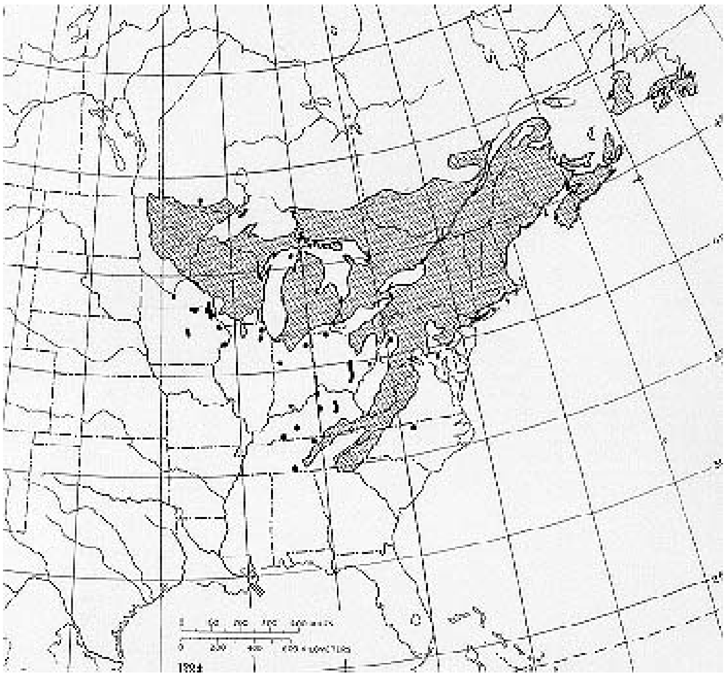

Fig 1. Native range of Yellow birch (USDA Forest Service, http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/alleghaniensis%20.htm).

Yellow birch requires sufficient light, crown expansion space, soil moisture, and nutrient to compete with other fast-growing associates. According to the study on 16- to 65-year old trees in Lake States and the Northeast, they respond well to release and can maintain themselves in competitive growing positions throughout their lives. (USDA Forest Service, http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/alleghaniensis%20.htm. April 24, 2006).

By removing important crown competitors or providing sufficient crown expansion space (6 to 8 ft for pole-size trees and 5 ft for saw log-size trees), diameter growth rates of pulpwood can be increased from 75 to 78 percent and for sawtimber the number can be increased by about 45 percent. Trees can attain an 18 in. d.b.h. in less than 90 years through careful tending with even-aged management techniques. Normally, yellow birch trees are financially mature at 22 in. in DBH (USDA Forest Service, http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/alleghaniensis%20.htm. April 24, 2006).

Stocking guides developed in the Lake States and the Northeast suggest leaving a residual stands with 60 to 80 percent of full stocking and retaining increasing amounts of basal area for even-aged stands as they mature. Dominant and codominant trees that have promising future grades should be left after thinning or crown release (USDA Forest Service, http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/alleghaniensis%20.htm. April 24, 2006).

Its DBH growth rates may be less than 1 in. in 20 years in unmanaged stands or stands managed under the uneven-aged system, which makes it one of the slowest growing hardwoods in the north. In the Lake States and New England, site index is about 55 to 65 ft at age 50. Trees grow faster in the Northeast than in the Lake States before age 50, but the trend reverses after age 50 (USDA Forest Service, http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/alleghaniensis%20.htm. April 24, 2006).

Yellow birch normally matures between 120 to 150 years of age in unmanaged forests (9). In New England, mature trees can attain a height of 100 ft and a d.b.h. of more than 30 in. by age 200. (USDA Forest Service, http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/alleghaniensis%20.htm. April 24, 2006).

The wood of yellow birch is heavy and strong. It is frequently used to manufacture furniture and flooring, veneer, plywood, cabinetry, interior finish, and items turned on a lathe. As one of the principal hardwoods, yellow birch is also used in the distillation of wood alcohol, acetate of lime, charcoal, tar, and oils. It is also an important browse plant for deer and moose. Other animals like songbirds and ruffed grouse feed on seeds, catkins and buds. (USDA Forest Service, http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/volume_2/betula/alleghaniensis%20.htm, NRCS USDA For. Serv. Plant guide http://plants.nrcs.usda.gov/plantguide/doc/pg_beal2.doc. April 24, 2006).

Economic background

Leak et al (1968) conducted a financial analysis on rates of value increase for yellow birch in New England. Initial stumpage value and future stumpage value after 10 years were estimated for 7 different lumber grades. The authors then calculated the compound interest rate of value increase over the 10 year period. Results of the paper indicate that yellow birch demonstrated the highest compound interests rate, which peaked at 8 percent, among tree species (yellow birch, sugar maple, yellow poplar, beech, black cherry, red maple, white ash and several of oaks) they studied.

Literature cited

Leak, W. B., S. M. Filip, and D. S. Solomon. 1968. Rates of value increase for yellow birch in New England. USDA For. Serv. Res. Pap. NE-120. 11p.

Species ___Yellow birch___________ Region ______Lake States_________________

Site indices 60, 70 and 80 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each site index had a corresponding height multiplier of 5.83, 6.50, and 7.83 from low to high site index. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 25 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183553598 and 0.489476260, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Perala and Alban (1994) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$Y = 0.05481D^{2.619}*1000$$

where:

Y = component dry-weight (kg.)

D = diameter at breast height (cm.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $150/mbf (International 1/4) (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005) and pulpwood price was assumed to be $17/cord (G. Banzhaf & Company 2000-2005, Prentiss & Carlisle 2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of yellow birch plantations in the Lake States.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$152.60	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]The seedling cost was estimated based on the seedling prices from Minnesota DNR State Forest Nursery (http://www.dnr.state.mn.us/forestry/nurseries/pricelist.html. January 18, 2006).

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Table 1. Total tons of carbon sequestered per acre for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	26.29	24.05	23.74	23.74	22.59	22.59
70	28.61	23.56	23.14	23.16	22.79	22.79
80	31.14	25.93	23.14	22.16	22.16	22.16

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	26.89	25.33	23.74	23.74	23.74	23.74
70	28.61	27.14	23.56	23.14	23.14	23.14
80	31.14	25.93	23.56	22.16	22.16	22.16

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	27.55	27.42	27.30	27.12	25.79	25.60
70	29.29	29.70	29.70	29.70	26.95	27.20
80	31.91	31.91	28.73	27.64	27.64	27.64

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	27.55	27.52	27.30	25.79	25.60	25.27
70	29.70	29.70	29.70	29.70	27.61	22.09
80	31.91	30.97	29.56	29.56	29.56	22.54

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<44-82-**87**[2]> (30%)[3]	<44-52-**77**>[4](30%)	<44-51-**77**> (30%)	<44-51-**77**> (30%)	<44-51-**72**> (30%)	<44-51-**72**> (30%)
70	<39-76-**87**> (30%)	<39-47-**71**> (30%)	<38-49-**71**> (30%)	<38-47-**71**> (30%)	<38-47-**70**> (30%)	<38-47-**70**> (30%)
80	<35-70-**90**> (30%)	<34-41-**74**> (30%)	<38-49-**71**> (30%)	<34-40-**65**> (30%)	<34-40-**65**> (30%)	<34-40-**65**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<44-82-**89**[2]> (30%)[3]	<45-52-**80**>[4](30%)	<44-51-**77**> (30%)	<44-51-**77**> (30%)	<44-51-**77**> (30%)	<44-51-**77**> (30%)
70	39-76-**87** (30%)	<38-49-**82**> (30%)	<39-47-**71**> (30%)	<38-49-**71**> (30%)	<38-49-**71**> (30%)	<38-49-**71**> (30%)
80	35-70-**90** (30%)	<34-41-**74**> (30%)	<39-47-**71**> (30%)	<34-40-**65**> (30%)	<34-40-**65**> (30%)	<34-40-**65**> (30%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	45-85-**90**[2] (30%)[3]	<58-85-**90>**[4](30%)	<63-85-**90>** (30%)	<67-79-**90>** (30%)	<74-81-**90>** (30%)	<75-81-**90>** (30%)
70	39-76-**89** (30%)	57-79-**90** (30%)	<57-79-**90>** (30%)	<57-79-**90>** (30%)	<61-83-**88>** (20%)	<64-82-**88>** (20%)
80	35-71-**90** (30%)	35-71-**90** (30%)	<54-73-**82>** (30%)	<56-75-**84>** (20%)	<56-75-**84>** (20%)	<56-75-**84>** (20%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	45-85-**90**[2] (30%)[3]	61-85-**90** (30%)	<63-85-**90**>[4] (30%)	<74-81-**90**> (30%)	<75-81-**90**> (30%)	<75-85-**90**> (30%)
70	39-76-**90** (30%)	57-79-**90** (30%)	<57-79-**90**> (30%)	<57-79-**90**> (30%)	<65-84-**90**> (20%)	<**90**>
80	35-71-**90** (30%)	54-74-**89** (25%)	<56-75-**89**> (20%)	<56-75-**89**> (20%)	<56-75-**89**> (20%)	<**89**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$195.01	-$368.54	-$396.02	-$399.72	-$399.45	-$398.71
70	-$116.46	-$354.29	-$391.36	-$398.12	-$398.86	-$398.46
80	-$43.42	-$338.24	-$391.36	-$395.39	-$397.76	-$397.98

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$22.72	-$275.94	-$337.66	-$360.49	-$371.51	-$377.81
70	$66.31	-$259.78	-$330.65	-$356.96	-$369.36	-$376.33
80	$152.73	-$236.46	-$330.65	-$352.24	-$366.57	-$374.46

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$454.24	-$12.48	-$176.28	-$253.10	-$295.40	-$321.13
70	$565.65	$20.21	-$160.62	-$243.38	-$288.58	-$316.08
80	$684.35	$52.22	-$144.05	-$232.46	-$280.79	-$310.20

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$684.52	$118.42	-$97.03	-$200.90	-$258.59	-$293.79
70	$809.12	$158.69	-$76.63	-$187.81	-$249.39	-$286.97
80	$941.01	$196.09	-$54.73	-$173.28	-$238.92	-$279.03

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$220.06	-$376.92	-$397.43	-$399.96	-$399.52	-$398.72
70	-$131.42	-$365.17	-$393.52	-$398.53	-$398.95	-$398.48
80	-$48.56	-$347.18	-$393.52	-$396.13	-$397.93	-$398.01

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$25.48	-$281.35	-$338.86	-$360.71	-$371.55	-$377.82
70	$74.82	-$264.39	-$332.47	-$357.34	-$369.44	-$376.35
80	$170.79	-$242.71	-$332.47	-$352.90	-$366.72	-$374.49

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$507.94	-$12.63	-$176.52	-$253.15	-$295.40	-$321.13
70	$634.38	$20.45	-$160.84	-$243.42	-$288.58	-$316.08
80	$765.24	$52.84	-$144.41	-$232.53	-$280.80	-$310.20

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the lakes states region. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$765.44	$119.83	-$97.16	-$200.94	-$258.59	-$293.79
70	$904.77	$160.59	-$76.74	-$187.84	-$249.39	-$286.97
80	$1,052.25	$198.55	-$54.81	-$173.31	-$238.92	-$279.03

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for yellow birch plantations by soil productivity and real alternative rates of return in the lakes states region). (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	44-82-**87**[3] (30%)[4]	656.73	0	498.25	2.58	1,628.90	6.69	2,783.88	9.27
	5.0%	44-52-**77** (30%)	656.73	0	566.21	0	1,357.70	7.02	2,580.64	7.02
	7.5%	44-51-**77** (30%)	656.73	0	564.67	0	1,336.48	6.91	2,557.88	6.91
	10.0%	44-51-**77** (30%)	656.73	0	564.67	0	1,336.48	6.91	2,557.88	6.91
	12.5%	44-51-**72** (30%)	656.73	0	564.67	0	1,887.45	4.06	3,108.85	4.06
	15.0%	44-51-**72** (30%)	656.73	0	564.67	0	1,887.45	4.06	3,108.85	4.06
70	2.5%	39-76-**87** (30%)	608.99	0	654.22	2.61	1,269.99	10.40	2,533.20	13.00
	5.0%	39-47-**71** (30%)	608.99	0	564.09	0	1,760.01	7.01	2,933.09	7.01
	7.5%	38-49 **71** (30%)	591.88	0	682.58	0	1,715.24	6.84	2,989.70	6.84
	10.0%	38-47-**71** (30%)	591.88	0	553.53	0	1,735.93	6.93	2,881.34	6.93
	12.5%	38-47-**70** (30%)	591.88	0	553.53	0	1,838.33	6.23	2,983.74	6.23
	15.0%	38-47-**70** (30%)	591.88	0	553.53	0	1,838.33	6.23	2,983.74	6.23
80	2.5%	35-70-**90** (30%)	571.58	0	776.86	2.57	1,250.28	14.70	2,598.72	17.27
	5.0%	34-41-**74** (30%)	560.51	0	610.90	0	1,789.21	10.88	2,960.62	10.88
	7.5%	38-49-**71** (30%)	591.88	0	682.58	0	1,715.24	6.84	2,989.70	6.84
	10.0%	34-40-**65** (30%)	560.51	0	591.18	0	2,062.26	6.83	3,213.95	6.83
	12.5%	34-40-**65** (30%)	560.51	0	591.18	0	2,062.26	6.83	3,213.95	6.83
	15.0%	34-40-**65** (30%)	560.51	0	591.18	0	2,062.26	6.83	3,213.95	6.83

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 18. Volume removed from the financially optimal schedules for yellow birch plantations by soil productivity and real alternative rates of return in the lakes states region. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	44-82-**89**[3] (30%)[4]	656.73	0	498.25	2.58	1,675.86	6.93	2,830.84	9.51
	5.0%	45-52-**80** (30%)	671.16	0	577.38	0	1,811.26	7.43	3,059.80	7.43
	7.5%	44-51-**77** (30%)	656.73	0	564.67	0	1,336.48	6.91	2,557.88	6.91
	10.0%	44-51-**77** (30%)	656.73	0	564.67	0	1,336.48	6.91	2,557.88	6.91
	12.5%	44-51-**77** (30%)	656.73	0	564.67	0	1,336.48	6.91	2,557.88	6.91
	15.0%	44-51-**77** (30%)	656.73	0	564.67	0	1,336.48	6.91	2,557.88	6.91
70	2.5%	39-76-**87** (30%)	608.99	0	654.22	2.61	1,269.99	10.40	2,533.20	13.00
	5.0%	38-49-**82** (30%)	591.88	0	682.58	0	1,398.99	11.10	2,673.45	11.10
	7.5%	39-47-**71** (30%)	608.99	0	564.09	0	1,760.01	7.01	2,933.09	7.01
	10.0%	38-49-**71** (30%)	591.88	0	682.58	0	1,715.24	6.84	2,989.70	6.84
	12.5%	38-49-**71** (30%)	591.88	0	682.58	0	1,715.24	6.84	2,989.70	6.84
	15.0%	38-49-**71** (30%)	591.88	0	682.58	0	1,715.24	6.84	2,989.70	6.84
80	2.5%	35-70-**90** (30%)	571.58	0	776.86	2.57	1,250.28	14.70	2,598.72	17.27
	5.0%	34-41-**74** (30%)	560.51	0	610.90	0	1,789.21	10.88	2,960.62	10.88
	7.5%	39-47-**71** (30%)	608.99	0	564.09	0	1,760.01	7.01	2,933.09	7.01
	10.0%	34-40-**65** (30%)	560.51	0	591.18	0	2,062.26	6.83	3,213.95	6.83
	12.5%	34-40-**65** (30%)	560.51	0	591.18	0	2,062.26	6.83	3,213.95	6.83
	15.0%	34-40-**65** (30%)	560.51	0	591.18	0	2,062.26	6.83	3,213.95	6.83

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 19. Volume removed from the financially optimal schedules for yellow birch plantations by soil productivity and real alternative rates of return in the lakes states region. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	45-85-**90** (30%)	671.16	0	530.67	2.69	1,699.85	7.02	2,901.68	9.71
	5.0%	58-85-**90** (30%)	827.32	0	490.51	2.54	1,614.21	6.64	2,932.04	9.18
	7.5%	63-85-**90** (30%)	921.54	0	475.75	2.46	1,579.57	6.48	2,976.86	8.94
	10.0%	67-79-**90** (30%)	1,038.20	0	629.83	1.35	1,615.73	6.65	3,283.76	8.00
	12.5%	74-81-**90** (30%)	1,042.28	0	591.40	1.27	1,500.61	6.15	3,134.29	7.42
	15.0%	75-81-**90** (30%)	1,042.29	0	582.68	1.25	1,481.21	6.07	3,106.18	7.32
70	2.5%	39-76-8**9** (30%)	608.99	0	654.22	2.61	1,303.98	10.76	2,567.19	13.36
	5.0%	57-79-**90** (30%)	997.18	0	629.80	2.51	1,220.57	10.01	2,847.55	12.52
	7.5%	57-79-**90** (30%)	997.18	0	629.80	2.51	1,220.57	10.01	2,847.55	12.52
	10.0%	57-79-**90** (30%)	997.18	0	629.80	2.51	1,220.57	10.01	2,847.55	12.52
	12.5%	61-83-**88** (20%)	683.65	0	442.82	1.77	1,898.45	7.77	3,024.92	9.54
	15.0%	64-82-**88** (20%)	691.40	0	439.45	1.75	1,910.56	7.82	3,041.41	9.57
80	2.5%	35-71-**90** (30%)	571.58	0	785.74	2.61	1,434.55	14.45	2,791.87	17.06
	5.0%	35-71-**90** (30%)	571.58	0	785.74	2.61	1,434.55	14.45	2,791.87	17.06
	7.5%	54-73-**82** (30%)	999.80	0	736.67	2.44	1,541.14	9.66	3,277.61	12.10
	10.0%	56-75-**84** (20%)	755.03	0	526.55	1.75	1,764.86	10.84	3,046.44	12.59
	12.5%	56-75-**84** (20%)	755.03	0	526.55	1.75	1,764.86	10.84	3,046.44	12.59
	15.0%	56-75-**84** (20%)	755.03	0	526.55	1.75	1,764.86	10.84	3,046.44	12.59

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).

Table 20. Volume removed from the financially optimal schedules for yellow birch plantations by soil productivity and real alternative rates of return in the lakes states region. (carbon value = $50/ton)

Site Index[1]	ARR	Schedule	1st thinning		2nd thinning		Final Harvest		Total Volume	
			Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.5%	45-85-**90**[3] (30%)[4]	671.16	0	530.67	2.69	1,699.85	7.02	2,901.68	9.71
	5.0%	61-85-**90** (30%)	854.70	0	482.38	2.50	1,599.28	6.57	2,936.36	9.07
	7.5%	63-85-**90** (30%)	921.54	0	475.75	2.46	1,579.57	6.48	2,976.86	8.94
	10.0%	74-81-**90** (30%)	1,042.28	0	591.40	1.27	1,500.61	6.15	3,134.29	7.42
	12.5%	75-81-**90** (30%)	1,042.29	0	582.68	1.25	1,481.21	6.07	3,106.18	7.32
	15.0%	75-85-**90** (30%)	1,042.29	0	614.88	1.33	1,391.19	5.79	3,048.36	7.12
70	2.5%	39-76-**90** (30%)	608.99	0	654.22	2.61	1,320.38	10.93	2,583.59	13.54
	5.0%	57-79-**90** (30%)	997.18	0	629.80	2.51	1,220.57	10.01	2,847.55	12.52
	7.5%	57-79-**90** (30%)	997.18	0	629.80	2.51	1,220.57	10.01	2,847.55	12.52
	10.0%	57-79-**90** (30%)	997.18	0	629.80	2.51	1,220.57	10.01	2,847.55	12.52
	12.5%	65-84-**90** (20%)	692.92	0	443.30	1.78	1,925.36	7.93	3,061.58	9.71
	15.0%	**90**	-[5]	-	-	-	2,221.52	9.06	2,221.52	9.06
80	2.5%	35-71-**90** (30%)	571.58	0	785.74	2.61	1,434.55	14.45	2,791.87	17.06
	5.0%	54-74-**89** (25%)	833.14	0	639.24	2.12	1,817.60	11.65	3,289.98	13.77
	7.5%	56-75-**89** (20%)	755.03	0	526.55	1.75	1,865.56	11.87	3,147.14	13.62
	10.0%	56-75-**89** (20%)	755.03	0	526.55	1.75	1,865.56	11.87	3,147.14	13.62
	12.5%	56-75-**89** (20%)	755.03	0	526.55	1.75	1,865.56	11.87	3,147.14	13.62
	15.0%	**89**	-	-	-	-	1,972.56	12.35	1,972.56	12.35

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for yellow birch plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	60	<44-82-**87**[2]>[3] (30%)[4]	<44-82-**89**> (30%)	2%	45-85-**90** (30%)	3%	45-85-**90** (30%)	3%
	70	<39-76 **87**> (30%)	<39-76-**87**> (30%)	0%	39-76-**89** (30%)	2%	39-76-**90** (30%)	3%
	80	<35-70-**90**> (30%)	35-70-**90** (30%)	0%	35-71-**90** (30%)	0%	35-71-**90** (30%)	0%
5.00%	60	<44-52-**77**> (30%)	<45-52-**80**>(30%)	4%	<58-85-**90**>(30%)	17%	61-85-**90** **(**30%)	17%
	70	<39-47-**71**> (30%)	<38-49-**82**> (30%)	15%	57-79-**90** (30%)	27%	57-79-**90** (30%)	27%
	80	<34-41-**74**> (30%)	<34-41-**74**> (30%)	0%	35-71-**90** (30%)	22%	54-74-**89** (25%)	20%
7.50%	60	<44-51-**77**> (30%)	<44-51-**77**> (30%)	0%	<63-85-**90**> (30%)	17%	<63-85-**90**>(30%)	17%
	70	<38-49-**71**> (30%)	<39-47-**71**> (30%)	0%	<57-79-**90**> (30%)	27%	<57-79-**90**> (30%)	27%
	80	<38-49-**71**> (30%)	<39-47-**71**> (30%)	0%	<54-73-**82**> (30%)	15%	<56-75-**89**> (20%)	25%
10.00%	60	<44-51-**77**> (30%)	<44-51-**77**> (30%)	0%	<67-79-**90**> (30%)	17%	<74-81-**90**> (30%)	17%
	70	<38-47-**71**> (30%)	<38-49-**71**> (30%)	0%	<57-79-**90**> (30%)	27%	<57-79-**90**> (30%)	27%
	80	<34-40-**65**> (30%)	<34-40-**65**> (30%)	0%	<56-75-**84**> (20%)	29%	<56-75-**89**> (20%)	37%
12.50%	60	<44-51-**72**> (30%)	<44-51-**77**> (30%)	7%	<74-81-**90**> (30%)	25%	<75-81-**90**> (30%)	25%
	70	<38-47-**70**> (30%)	<38-49-**71**> (30%)	1%	<61-83-**88**> (20%)	26%	<65-84-**90**> (20%)	29%
	80	<34-40-**65**> (30%)	<34-40-**65**> (30%)	0%	<56-75-**84**> (20%)	29%	<56-75-**89**> (20%)	37%
15.00%	60	<44-51-**72**> (30%)	<44-51-**77**> (30%)	7%	<75-81-**90**> (30%)	25%	<75-85-**90**> (30%)	25%
	70	<38-47-**70**> (30%)	<38-49-**71**> (30%)	1%	<64-82-**88**> (20%)	26%	<**90**>	29%
	80	<34-40-**65**> (30%)	<34-40-**65**> (30%)	0%	<56-75-**84**> (20%)	29%	<**89**>	37%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

[4]Number in parentheses indicates the percentage of basal area removed during thinning

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for yellow birch plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	60	-220.06	-25.48		507.94		765.44	
	70	-131.42	-74.82		634.38		904.77	
	80	-48.56	170.79		765.24		1,052.25	
5.00%	60	-376.92	-281.35		-12.63		119.83	
	70	-365.17	-264.39		20.45		160.59	
	80	-347.18	-242.71		52.84		198.55	
7.50%	60	-397.43	-338.86		-176.52		-97.16	
	70	-393.52	-332.47		-160.84		-76.74	
	80	-393.52	-332.47		-144.41		-54.81	
10.00%	60	-399.96	-360.71		-253.15		-200.94	
	70	-398.53	-357.34		-243.42		-187.84	
	80	-396.13	-352.90		-232.53		-173.31	
12.50%	60	-399.52	-371.55		-295.40		-258.59	
	70	-398.95	-369.44		-288.58		-249.39	
	80	-397.93	-366.72		-280.80		-238.92	
15.00%	60	-398.72	-377.82		-321.13		-293.79	
	70	-398.48	-376.35		-316.08		-286.97	
	80	-398.01	-374.49		-310.20		-279.03	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

Lake States- Yellow birch - Timber Only Rotations (C = $0/ton)

Yellow birch, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 82 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 5). This optimal management regime will generate the maximum SEV of -$220.06 (Table 13), with a NPW of -$195.01 per acre (Table 9). This means that -$220.06 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$195.01 per acre for managing one rotation, or -$220.06 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,783.88 cubic feet of pulpwood and 9.27 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 26.29 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Yellow birch, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 5). This optimal management regime will generate the maximum SEV of -$376.92 (Table 13), with a NPW of -$368.54 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,580.64 cubic feet of pulpwood and 7.02 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 24.05 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 5). This optimal management regime will generate the maximum SEV of -$397.43 (Table 13), with a NPW of -$396.02 per acre (Table 9). This financially optimal rotation would produce an estimated 2,557.88 cubic feet of pulpwood and 6.91 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.74 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 5). This optimal management regime will generate the maximum SEV of -$399.96 (Table 13), with a NPW of -$399.72 per acre (Table 9). This financially optimal rotation would produce an estimated 2,557.88 cubic feet of pulpwood and 6.91 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.74 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 72 (Table 5). This optimal management regime will generate the maximum SEV of -$399.52 (Table 13), with a NPW of -$399.45 per acre (Table 9). This financially optimal rotation would produce an estimated 3,108.85 cubic feet of pulpwood and 4.06 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.59 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 72 (Table 5). This optimal management regime will generate the maximum SEV of -$398.72 (Table 13), with a NPW of -$398.71 per acre (Table 9). This financially optimal rotation would produce an estimated 3,108.85 cubic feet of pulpwood and 4.06 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.59 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 76 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 5). This optimal management regime will generate the maximum SEV of -$131.42 (Table 13), with a NPW of -$116.46 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,533.20 cubic feet of pulpwood and 13.00 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 28.61 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71(Table 5). This optimal management regime will generate the maximum SEV of -$365.17 (Table 13), with a NPW of -$354.29 per acre (Table 9). This financially optimal rotation would produce an estimated 2,933.09 cubic feet of pulpwood and 7.01 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.56 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 5). This optimal management regime will generate the maximum SEV of -$393.52 (Table 13), with a NPW of -$391.36 per acre (Table 9). This financially optimal rotation would produce an estimated 2,989.70 cubic feet of pulpwood and 6.84 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.14 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 5). This optimal management regime will generate the maximum SEV of -$398.53 (Table 13), with a NPW of -$398.12 per acre (Table 9). This financially optimal rotation would produce an estimated 2,881.34 cubic feet of pulpwood and 6.93 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.16 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 70 (Table 5). This optimal management regime will generate the maximum SEV of -$398.95 (Table 13), with a NPW of -$398.86 per acre (Table 9). This financially optimal rotation would produce an estimated 2,983.74 cubic feet of pulpwood and 6.23 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.79 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 70 (Table 5). This optimal management regime will generate the maximum SEV of -$398.48 (Table 13), with a NPW of -$398.46 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,983.74 cubic feet of pulpwood and 6.23 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.79 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 70 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 5). This optimal management regime will generate the maximum SEV of -$48.56 (Table 13), with a NPW of -$43.42 per acre (Table 9). This financially optimal rotation would produce an estimated 2,598.72 cubic feet of pulpwood and 17.27 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 31.14 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 5). This optimal management regime will generate the maximum SEV of -$347.18 (Table 13), with a NPW of -$338.24 per acre (Table 9). This financially optimal rotation would produce an estimated 2,960.62 cubic feet of pulpwood and 10.88 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 25.93 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 5). This optimal management regime will generate the maximum SEV of -$393.52 (Table 13), with a NPW of -$391.36 per acre (Table 9). This financially optimal rotation would produce an estimated 2,989.70 cubic feet of pulpwood and 6.84 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 23.14 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 5). This optimal management regime will generate the maximum SEV of -$396.13 (Table 13), with a NPW of -$395.39 per acre (Table 9). This financially optimal rotation would produce an estimated 3,213.95 cubic feet of pulpwood and 6.83 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.16 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 5). This optimal management regime will generate the maximum SEV of -$397.93 (Table 13), with a NPW of -$397.76 per acre (Table 9). This financially optimal rotation would

produce an estimated 3,213.95 cubic feet of pulpwood and 6.83 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.16 net tons of carbon per acre during one rotation (Table 1).

Yellow birch, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 5). This optimal management regime will generate the maximum SEV of -$398.01 (Table 13), with a NPW of -$397.98 per acre (Table 9). This financially optimal rotation would produce an estimated 3,213.95 cubic feet of pulpwood and 6.83 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 22.16 net tons of carbon per acre during one rotation (Table 1).

<u>Lake States- Yellow birch - Timber Only Rotations (C = $10/ton)</u>

Yellow birch, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 82 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 6). This optimal management regime will generate the maximum SEV of -$25.48 (Table 14), with a NPW of -$22.72 per acre (Table 10). This means that -$25.48 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$22.72 per acre for managing one rotation, or -$25.48 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,830.84 cubic feet of pulpwood and 9.51 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 26.89 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Yellow birch, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 52 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 80 (Table 6). This optimal management regime will generate the maximum SEV of -$281.35 (Table 14), with a NPW of -$275.94 per acre (Table 10). This financially optimal rotation would produce an estimated 3,059.80 cubic feet of pulpwood and 7.43 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.33 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 6). This optimal management regime will generate the maximum SEV of -$338.86 (Table 14), with a NPW of -$337.66 per acre (Table 10). This financially optimal rotation would produce an estimated 2,557.88 cubic feet of pulpwood and 6.91 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 23.74 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 6). This optimal management regime will generate the maximum SEV of -$360.71 (Table 14), with a NPW of -$360.49 per acre (Table 10). This financially optimal rotation would produce an estimated 2,557.88 cubic feet of pulpwood and 6.91 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.74 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 51 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 6). This optimal management regime will generate the maximum SEV of -$371.00 (Table 14), with a NPW of -$371.51 per acre (Table 10). This financially optimal rotation would produce an estimated 2,557.88 cubic feet of pulpwood and 6.91 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.74 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 44 and 51 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 77 (Table 6). This optimal management regime will generate the maximum SEV of -$377.82 (Table 14), with a NPW of -$377.81 per acre (Table 10). This financially optimal rotation would produce an estimated 2,557.88 cubic feet of pulpwood and 6.91 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.74 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 76 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 87 (Table 6). This optimal management regime will generate the maximum SEV of $74.82 (Table 14), with a NPW of $66.31 per acre (Table 10). This financially optimal rotation would produce an estimated 2,533.20 cubic feet of pulpwood and 13.00 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 28.61 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 6). This optimal management regime will generate the maximum SEV of -$264.39 (Table 14), with a NPW of -$259.78 per acre (Table 10). This financially optimal rotation would produce an estimated 2,673.45 cubic feet of pulpwood and 11.10 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 27.14 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 6). This optimal management regime will generate the maximum SEV of -$332.47 (Table 14), with a NPW of -$330.65 per acre (Table 10). This financially optimal rotation would produce an estimated 2,933.09 cubic feet of pulpwood and 7.01 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.56 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 6). This optimal management regime will generate the maximum SEV of -$357.34 (Table 14), with a NPW of -$356.96 per acre (Table 10). This financially optimal rotation would produce an estimated 2,989.70 cubic feet of pulpwood and 6.84 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.14 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 49 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 6). This optimal management regime will generate the maximum SEV of -$369.44 (Table 14), with a NPW of -$369.36 per acre (Table 10). This financially optimal rotation would produce an estimated 2,989.70 cubic feet of pulpwood and 6.84 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.14 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 38 and 49 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 6). This optimal management regime will generate the maximum SEV of -$376.35 (Table 14), with a NPW of -$376.33 per acre (Table 10). This financially optimal rotation would produce an estimated 2,989.70 cubic feet of pulpwood and 6.84 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.14 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 70 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 6). This optimal management regime will generate the maximum SEV of $170.79 (Table 14), with a NPW of $152.73 per acre (Table 10). This financially optimal rotation would produce an estimated 2,598.72 cubic feet of pulpwood and 17.27 MBF of sawlogs per

acre from the thinning and final harvest (Table 18), and sequester 31.14 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 74 (Table 6). This optimal management regime will generate the maximum SEV of -$242.71 (Table 14), with a NPW of -$236.46 per acre (Table 10). This financially optimal rotation would produce an estimated 2,960.62 cubic feet of pulpwood and 10.33 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 25.93 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 47 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 71 (Table 6). This optimal management regime will generate the maximum SEV of -$332.47 (Table 14), with a NPW of -$330.65 per acre (Table 10). This financially optimal rotation would produce an estimated 2,933.09 cubic feet of pulpwood and 7.01 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 23.56 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 40 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 6). This optimal management regime will generate the maximum SEV of -$352.90 (Table 14), with a NPW of -$352.24 per acre (Table 10). This financially optimal rotation would produce an estimated 3,213.95 cubic feet of pulpwood and 6.83 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.16 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 6). This optimal management regime will generate the maximum SEV of -$366.72 (Table 14), with a NPW of -$366.57 per acre (Table 10). This financially optimal rotation would produce an estimated 3,213.95 cubic feet of pulpwood and 6.83 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 22.16 net tons of carbon per acre during one rotation (Table 2).

Yellow birch, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 40 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 65 (Table 6). This optimal management regime will generate the maximum SEV of -$374.49 (Table 14), with a NPW of -$374.46 per acre (Table 10). This financially optimal rotation would produce an estimated 3,213.95 cubic feet of pulpwood and 6.83 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 22.16 net tons of carbon per acre during one rotation (Table 2).

<u>Lake States-Yellow birch - Timber Only Rotations (C = $37/ton)</u>

Yellow birch, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $507.94 (Table 15), with a NPW of $454.24 per acre (Table 11). This means that $507.94 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $454.24 per acre for managing one rotation, or $507.94 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,901.68 cubic feet of pulpwood and 9.71 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 27.55 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Yellow birch, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 58 and 85 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$12.63 (Table 15), with a NPW of -$12.48 per acre (Table 11). This financially optimal rotation would produce an estimated 2,932.04 cubic feet of pulpwood and 9.18 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 27.42 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 63 and 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$176.52 (Table 15), with a NPW of -$176.28 per acre (Table 11). This financially optimal rotation would produce an estimated 2,976.86 cubic feet of pulpwood and 8.94 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 27.30 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 67 and 79 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$253.15 (Table 15), with a NPW of -$253.10 per acre (Table 11). This financially optimal rotation would produce an estimated 3,283.76 cubic feet of pulpwood and 8.00 MBF of sawlogs

per acre from the thinning and final harvest (Table 19), and sequester 27.12 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 74 and 81 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$295.40 (Table 15), with a NPW of -$295.40 per acre (Table 11). This financially optimal rotation would produce an estimated 3,134.29 cubic feet of pulpwood and 7.42 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 25.79 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 81 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$321.13 (Table 15), with a NPW of -$321.13 per acre (Table 11). This financially optimal rotation would produce an estimated 3,106.18 cubic feet of pulpwood and 7.32 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 25.60 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 76 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 7). This optimal management regime will generate the maximum SEV of $634.38 (Table 15), with a NPW of $565.65 per acre (Table 11). This financially optimal rotation would produce an estimated 2,567.19 cubic feet of pulpwood and 13.36 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 29.29 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 79 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $20.45 (Table 15), with a NPW of $20.21 per acre (Table 11). This financially optimal rotation would produce an estimated 2,847.55 cubic feet of pulpwood and 12.52 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 29.70 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 79 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$160.84 (Table 15), with a NPW of -$160.62 per acre (Table 11). This financially optimal rotation would produce an estimated 2,847.55 cubic feet of pulpwood and 12.52 MBF of sawlogs

per acre from the thinning and final harvest (Table 19), and sequester 29.70 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 79 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of -$243.42 (Table 15), with a NPW of -$243.38 per acre (Table 11). This financially optimal rotation would produce an estimated 2,847.55 cubic feet of pulpwood and 12.52 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 29.70 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 61 and 83 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 7). This optimal management regime will generate the maximum SEV of -$288.58 (Table 15), with a NPW of -$288.58 per acre (Table 11). This financially optimal rotation would produce an estimated 3,024.92 cubic feet of pulpwood and 9.54 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 26.95 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 64 and 82 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 88 (Table 7). This optimal management regime will generate the maximum SEV of -$316.08 (Table 15), with a NPW of -$316.08 per acre (Table 11). This financially optimal rotation would produce an estimated 3,041.41 cubic feet of pulpwood and 9.57 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 27.20 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 71 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $765.24 (Table 15), with a NPW of $684.35 per acre (Table 11). This financially optimal rotation would produce an estimated 2,791.87 cubic feet of pulpwood and 17.06 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 31.91 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 71 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 7). This optimal management regime will generate the maximum SEV of $52.84 (Table 15), with a NPW of $52.22 per acre (Table 11). This financially optimal rotation would produce an estimated 2,791.87 cubic feet of pulpwood and 17.06 MBF of sawlogs per

acre from the thinning and final harvest (Table 19), and sequester 31.91 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 54 and 73 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 82 (Table 7). This optimal management regime will generate the maximum SEV of -$144.41 (Table 15), with a NPW of -$144.05 per acre (Table 11). This financially optimal rotation would produce an estimated 3,227.61 cubic feet of pulpwood and 12.10 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 28.73 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 56 and 75 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 7). This optimal management regime will generate the maximum SEV of -$232.53 (Table 15), with a NPW of -$232.46 per acre (Table 11). This financially optimal rotation would produce an estimated 3,046.44 cubic feet of pulpwood and 12.59 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 27.64 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 56 and 75 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 7). This optimal management regime will generate the maximum SEV of -$280.80 (Table 15), with a NPW of -$280.79 per acre (Table 11). This financially optimal rotation would produce an estimated 3,046.44 cubic feet of pulpwood and 12.59 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 27.64 net tons of carbon per acre during one rotation (Table 3).

Yellow birch, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 56 and 75 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 84 (Table 7). This optimal management regime will generate the maximum SEV of -$310.20 (Table 15), with a NPW of -$310.20 per acre (Table 11). This financially optimal rotation would produce an estimated 3,046.44 cubic feet of pulpwood and 12.59 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 27.64 net tons of carbon per acre during one rotation (Table 3).

<u>Lake States- Yellow birch - Timber Only Rotations (C = $50/ton)</u>

Yellow birch, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 45 and 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $765.44 (Table 16), with a NPW of $684.52 per acre (Table 12). This means that $765.44 is the

maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $684.52 per acre for managing one rotation, or $765.44 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,901.68 cubic feet of pulpwood and 9.71 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 27.55 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Yellow birch, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 61 and 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $119.83 (Table 16), with a NPW of $118.42 per acre (Table 12). This financially optimal rotation would produce an estimated 2,936.36 cubic feet of pulpwood and 9.07 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 27.52 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 63 and 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8).

This optimal management regime will generate the maximum SEV of -$97.16 (Table 16), with a NPW of -$97.03 per acre (Table 12). This financially optimal rotation would produce an estimated 2,976.86 cubic feet of pulpwood and 8.94 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 27.30 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 74 and 81 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$200.94 (Table 16), with a NPW of -$200.90 per acre (Table 12). This financially optimal rotation would produce an estimated 3,134.29 cubic feet of pulpwood and 7.42 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.79 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 81 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$258.59 (Table 16), with a NPW of -$258.59 per acre (Table 12). This financially optimal rotation would produce an estimated 3,106.18 cubic feet of pulpwood and 7.32 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.60 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 75 and 85 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$293.79 (Table 16), with a NPW of -$293.79 per acre (Table 12). This financially optimal rotation would produce an estimated 3,048.36 cubic feet of pulpwood and 7.12 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 25.27 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 39 and 76 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $904.77 (Table 16), with a NPW of $809.12 per acre (Table 12). This financially optimal rotation would produce an estimated 2,583.59 cubic feet of pulpwood and 13.54 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.70 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 79 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $160.59 (Table

16), with a NPW of $158.69 per acre (Table 12). This financially optimal rotation would produce an estimated 2,847.55 cubic feet of pulpwood and 12.52 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.70 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 79 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$76.74 (Table 16), with a NPW of -$76.63 per acre (Table 12). This financially optimal rotation would produce an estimated 2,847.55 cubic feet of pulpwood and 12.52 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.70 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 57 and 79 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$187.84 (Table 16), with a NPW of -$187.81 per acre (Table 12). This financially optimal rotation would produce an estimated 2,847.55 cubic feet of pulpwood and 12.52 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.70 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 65 and 84 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$249.39 (Table 16), with a NPW of -$249.39 per acre (Table 12). This financially optimal rotation would produce an estimated 3,061.58 cubic feet of pulpwood and 9.71 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 27.61 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of -$286.97 (Table 16), with a NPW of -$286.97 per acre (Table 12). This financially optimal rotation would produce an estimated 2,221.52 cubic feet of pulpwood and 9.06 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 22.09 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 71 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 8). This optimal management regime will generate the maximum SEV of $1,052.25 (Table 16), with a NPW of $941.01 per acre (Table 12). This financially optimal rotation would produce an estimated 2,791.87 cubic feet of pulpwood and 17.06 MBF of sawlogs per

acre from the thinning and final harvest (Table 20), and sequester 31.91 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 54 and 74 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of $198.55 (Table 16), with a NPW of $196.09 per acre (Table 12). This financially optimal rotation would produce an estimated 3,289.98 cubic feet of pulpwood and 13.77 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 30.97 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 56 and 75 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of -$54.81 (Table 16), with a NPW of $54.73 per acre (Table 12). This financially optimal rotation would produce an estimated 3,147.14 cubic feet of pulpwood and 13.62 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.56 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 56 and 75 (with 20

percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of -$173.31 (Table 16), with a NPW of -$173.28 per acre (Table 12). This financially optimal rotation would produce an estimated 3,147.14 cubic feet of pulpwood and 13.62 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.56 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 56 and 75 (with 20 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of -$238.92 (Table 16), with a NPW of -$238.92 per acre (Table 12). This financially optimal rotation would produce an estimated 3,147.14 cubic feet of pulpwood and 13.62 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 29.56 net tons of carbon per acre during one rotation (Table 4).

Yellow birch, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 8). This optimal management regime will generate the maximum SEV of -$279.03 (Table 16), with a NPW of -$279.03 per acre (Table 12). This financially optimal rotation would produce an estimated 1,972.56 cubic feet of pulpwood and 12.35 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 22.54 net tons of carbon per acre during one rotation (Table 4).

Species___yellow birch__________ Region______Northeast_________________

Site indices 60, 70 and 80 (base age 50), the range of site indices most commonly observed, were used in the analyses. Each SI had a corresponding height multiplier of 5.30, 6.20, and 7.30 from low to high SI. Sawlog volume was measured in International 1/4 to a 9.6-in. inside bark top diameter for trees with a minimum of 11 in diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 5- to 10-in. dbh classes. The maximum possible rotation length was limited to age 90 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 20 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 20, 25 and 30% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.183628319 and 0.553097345, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. The dry weight equation developed by Pastor. et al. (1984) was used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equation was:

$$\mathrm{Ln}(Y) = 5.1428+2.3729*\ln(D)$$

where:

Y = weight in g

D = diameter breast height(cm.).

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 0.2% and 0% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisors 2005). The price of sawtimber was assumed to be $117/mbf (International 1/4) (WVU Division of Forestry, http://ahc.caf.wvu.edu/., University of Maryland, http://www.naturalresources.umd.edu/Stumpage_Prices.cfm., Universities of Connecticut and Massachusetts, http://forest.fnr.umass.edu/snestumpage.htm., University of Vermont Extension, http://stumpage.uvm.edu/stumpage.php., Maine Department of Conservation, http://www.state.me.us/doc/mfs/pubs.htm. February 3, 2006) and pulpwood price was assumed to be $8.66/cord (WVU Division of Forestry, http://ahc.caf.wvu.edu/., University of Maryland, http://www.naturalresources.umd.edu/Stumpage_Prices.cfm., Universities of Connecticut and Massachusetts, http://forest.fnr.umass.edu/snestumpage.htm., University of Vermont Extension, http://stumpage.uvm.edu/stumpage.php., Maine Department of Conservation, http://www.state.me.us/doc/mfs/pubs.htm. February 3, 2006). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of yellow birch plantations in the Northeast.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[b]	$60.00	Only once	Year 0	
Seedlings[c] (436 seedlings/ac)	$218.00	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).
[b]Data from Hans M. Williams, personal communications, Stephen F. Austin State University, December 19, 2005.
[c]Data from Gary D. Kronrad, personal communications, Stephen F. Austin State University, February 8, 2005.

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Table 23. Total tons of carbon sequestered per acre for yellow birch plantations in the Northeast United States by site index and real alternative rates of return. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	23.94	23.92	24.47	24.02	24.07	24.07
70	28.53	27.83	27.83	27.83	27.83	27.31
80	28.81	28.81	28.81	28.78	28.78	28.78

[1]Base age 50.

Table 24. Total tons of carbon sequestered per acre for yellow birch plantations in the Northeast United States by site index and real alternative rates of return. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	24.03	24.07	24.07	24.07	24.07	24.07
70	28.42	25.87	25.87	26.02	25.87	25.87
80	28.81	28.78	28.78	28.78	28.78	28.78

[1]Base age 50.

Table 25. Total tons of carbon sequestered per acre for yellow birch plantations in the Northeast United States by site index and real alternative rates of return. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	24.07	24.07	24.07	24.07	24.07	24.07
70	26.13	25.87	25.87	25.87	25.87	25.87
80	28.81	28.78	28.78	28.78	28.78	28.78

[1]Base age 50.

Table 26. Total tons of carbon sequestered per acre for yellow birch plantations in the Northeast United States by site index and real alternative rates of return. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	24.07	24.07	24.07	24.07	24.07	24.07
70	26.13	25.87	25.87	25.87	25.87	25.87
80	28.81	28.78	28.78	28.78	28.78	28.78

[1]Base age 50.

Table 27. Financially optimal thinning and final harvest schedules which maximize soil expectation value for yellow birch plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<81-**89**[2] >[3] (30%)[4]	<81-**90**> (30%)	<78-**90**> (30%)	<81-**90**> (25%)	<**90**>	<**90**>
70	<49-69-**89**> (30%)	<46-69-**90**> (30%)	<46-69-**90**> (30%)	<46-69-**90**> (30%)	<46-69-**90**> (30%)	<46-**89**> (30%)
80	<**89**>	<**89**>	<**89**>	<**90**>	<**90**>	<**90**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 28. Financially optimal thinning and final harvest schedules which maximize soil expectation value for yellow birch plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	<82-**89**[2] >[3] (25%)[4]	<**90**>	<**90**>	<**90**>	<**90**>	<**90**>
70	<49-78-**89**> (30%)	<**90**>	<**90**>	<85-**90**> (25%)	<**90**>	<**90**>
80	<**89**>	<**90**>	<**90**>	<**90**>	<**90**>	<**90**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.
[4]Number in parentheses indicates the percentage of basal area removed during thinning(s).

Table 29. Financially optimal thinning and final harvest schedules which maximize soil expectation value for yellow birch plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	**90**[2]	**90**	<**90**>[3]	<**90**>	<**90**>	<**90**>
70	**89**	**90**	<**90**>	<**90**>	<**90**>	<**90**>
80	**89**	**90**	**90**	<**90**>	<**90**>	<**90**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 30. Financially optimal thinning and final harvest schedules which maximize soil expectation value for yellow birch plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	**90**[2]	**90**	<**90**>[3]	<**90**>	<**90**>	<**90**>
70	**89**	**90**	**90**	<**90**>	<**90**>	<**90**>
80	**89**	**90**	**90**	**90**	<**90**>	<**90**>

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 31. Net present worth of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$479.12	-$476.40	-$470.91	-$467.61	-$465.63	-$464.37
70	-$466.21	-$472.24	-$469.54	-$467.15	-$465.47	-$464.31
80	-$408.95	-$410.34	-$405.44	-$402.21	-$400.23	-$398.97

[1]Base age 50.

Table 32. Net present worth of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$276.82	-$341.60	-$376.92	-$397.73	-$411.04	-$420.16
70	-$246.07	-$323.00	-$363.26	-$363.29	-$402.62	-$413.28
80	-$157.31	-$240.25	-$284.90	-$311.58	-$328.95	-$341.01

[1]Base age 50.

Table 33. Net present worth of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$275.07	$23.21	-$122.99	-$209.01	-$263.66	-$300.80
70	$368.26	$90.70	-$72.61	-$169.97	-$232.50	-$275.36
80	$522.10	$219.78	$40.68	-$66.88	-$136.50	-$184.55

[1]Base age 50.

Table 34. Net present worth of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$541.18	$198.85	-$0.73	-$118.15	-$192.69	-$243.33
70	$664.85	$289.89	$67.33	-$65.39	-$150.59	-$208.95
80	$849.23	$441.28	$197.44	$50.94	-$43.84	-$109.21

[1]Base age 50.

Table 35. Soil expectation value of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $0/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$537.35	-$482.09	-$471.56	-$467.69	-$465.64	-$464.37
70	-$522.87	-$477.88	-$470.20	-$467.23	-$465.48	-$464.31
80	-$458.65	-$415.49	-$406.05	-$402.28	-$400.24	-$398.97

[1]Base age 50.

Table 36. Soil expectation value of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	-$310.46	-$345.68	-$377.44	-$397.79	-$411.05	-$420.16
70	-$275.97	-$326.86	-$363.77	-$363.79	-$402.63	-$413.28
80	-$176.43	-$243.12	-$285.30	-$311.63	-$328.96	-$341.02

[1]Base age 50.

Table 37. Soil expectation value of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$307.59	$23.48	-$123.16	-$209.05	-$263.66	-$300.80
70	$413.01	$91.78	-$72.71	-$170.00	-$232.50	-$275.36
80	$585.55	$222.40	$40.74	-$66.89	-$136.51	-$184.55

[1]Base age 50.

Table 38. Soil expectation value of the financially optimal thinning and final harvest schedules for yellow birch plantations by site index and real alternative rates of return in the Northeast United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
60	$605.15	$201.23	-$0.73	-$118.17	-$192.70	-$243.33
70	$745.65	$293.35	$67.42	-$65.41	-$150.59	-$208.95
80	$952.43	$446.54	$197.72	$50.95	-$43.84	-$109.21

[1]Base age 50.

Table 39. Volume removed from the financially optimal schedules for yellow birch plantations by soil productivity and real alternative rates of return in the Northeast United States. (carbon value = $0/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.50%	<81-**89**[3]>[4] (30%)[5]	700.79	0	-	-	1,777.10	0	2,477.89	0
	5.00%	<81-**90**> (30%)	700.79	0	-	-	1,793.66	0	2,494.45	0
	7.50%	<78-**90**> (30%)	553.49	0	-	-	1,821.70	0	2,375.19	0
	10.00%	<81-**90**> (25%)	583.99	0	-	-	1,902.00	0	2,485.99	0
	12.50%	<**90**>	-[6]	-	-	-	2,465.00	0	2,465.00	0
	15.00%	<**90**>	-	-	-	-	2,465.00	0	2,465.00	0
70	2.50%	<49-69-**89**> (30%)	584.45	0	552.08	0	2,065.68	0	3,202.21	0
	5.00%	<46-69-**90**> (30%)	564.24	0	556.91	0	2,009.92	0	3,131.07	0
	7.50%	<46-69-**90**> (30%)	564.24	0	556.91	0	2,009.92	0	3,131.07	0
	10.00%	<46-69-**90**> (30%)	564.24	0	556.91	0	2,009.92	0	3,131.07	0
	12.50%	<46-69-**90**> (30%)	564.24	0	556.91	0	2,009.92	0	3,131.07	0
	15.00%	<46-**89**> (30%)	564.24	0			2,582.05	0	3,146.29	0
80	2.50%	<**89**>	-	-	-	-	3,336.29	0	3,336.29	0
	5.00%	<**89**>	-	-	-	-	3,336.29	0	3,336.29	0
	7.50%	<**89**>	-	-	-	-	3,336.29	0	3,336.29	0
	10.00%	<**90**>	-	-	-	-	3,365.85	0	3,365.85	0
	12.50%	<**90**>	-	-	-	-	3,365.85	0	3,365.85	0
	15.00%	<**90**>	-	-	-	-	3,365.85	0	3,365.85	0

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4] Brackets indicates a negative SEV. Schedule shown minimizes losses.
[5]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[6]Indicates no operation conducted.

Table 40. Volume removed from the financially optimal schedules for yellow birch plantations by soil productivity and real alternative rates of return in the Northeast United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.50%	<82-**89**[3]>[4] (25%)[5]	588.72	0	-	-	1,883.15	0	2,471.87	0
	5.00%	<**90**>	-[6]	-	-	-	2,465.00	0	2,465.00	0
	7.50%	<**90**>	-	-	-	-	2,465.00	0	2,465.00	0
	10.00%	<**90**>	-	-	-	-	2,465.00	0	2,465.00	0
	12.50%	<**90**>	-	-	-	-	2,465.00	0	2,465.00	0
	15.00%	<**90**>	-	-	-	-	2,465.00	0	2,465.00	0
70	2.50%	<49-78-**89**> (30%)	584.45	0	717.79	0	1,976.76	0	3,279.00	0
	5.00%	<**90**>	-	-	-	-	3,108.22	0	3,108.22	0
	7.50%	<**90**>	-	-	-	-	3,108.22	0	3,108.22	0
	10.00%	<85-**90**> (25%)	648.36	0	-	-	2,375.91	0	3,024.27	0
	12.50%	<**90**>	-	-	-	-	3,108.22	0	3,108.22	0
	15.00%	<**90**>	-	-	-	-	3,108.22	0	3,108.22	0
80	2.50%	<**89**>	-	-	-	-	3,336.29	0	3,336.29	0
	5.00%	<**90**>	-	-	-	-	3,365.85	0	3,365.85	0
	7.50%	<**90**>	-	-	-	-	3,365.85	0	3,365.85	0
	10.00%	<**90**>	-	-	-	-	3,365.85	0	3,365.85	0
	12.50%	<**90**>	-	-	-	-	3,365.85	0	3,365.85	0
	15.00%	<**90**>	-	-	-	-	3,365.85	0	3,365.85	0

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4] Brackets indicates a negative SEV. Schedule shown minimizes losses.
[5]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[6]Indicates no operation conducted.

Table 41. Volume removed from the financially optimal schedules for yellow birch plantations by soil productivity and real alternative rates of return in the Northeast United States. (carbon value = $37/ton)

Site Index[1]	ARR	Schedule	1st thinning Cu. Ft.	1st thinning MBF[2]	2nd thinning Cu. Ft.	2nd thinning MBF	Final Harvest Cu. Ft.	Final Harvest MBF	Total Volume Cu. Ft.	Total Volume MBF
60	2.50%	**90**[3]	-[5]	-	-	-	2,465.00	0	2,465.00	0
	5.00%	**90**	-	-	-	-	2,465.00	0	2,465.00	0
	7.50%	<**90**>[4]	-	-	-	-	2,465.00	0	2,465.00	0
	10.00%	<**90**>	-	-	-	-	2,465.00	0	2,465.00	0
	12.50%	<**90**>	-	-	-	-	2,465.00	0	2,465.00	0
	15.00%	<**90**>	-	-	-	-	2,465.00	0	2,465.00	0
70	2.50%	**89**	-	-	-	-	3,110.69	0	3,110.69	0
	5.00%	**90**	-	-	-	-	3,108.22	0	3,108.22	0
	7.50%	<**90**>	-	-	-	-	3,108.22	0	3,108.22	0
	10.00%	<**90**>	-	-	-	-	3,108.22	0	3,108.22	0
	12.50%	<**90**>	-	-	-	-	3,108.22	0	3,108.22	0
	15.00%	<**90**>	-	-	-	-	3,108.22	0	3,108.22	0
80	2.50%	**89**	-	-	-	-	3,336.29	0	3,336.29	0
	5.00%	**90**	-	-	-	-	3,365.85	0	3,365.85	0
	7.50%	**90**	-	-	-	-	3,365.85	0	3,365.85	0
	10.00%	<**90**>	-	-	-	-	3,365.85	0	3,365.85	0
	12.50%	<**90**>	-	-	-	-	3,365.85	0	3,365.85	0
	15.00%	<**90**>	-	-	-	-	3,365.85	0	3,365.85	0

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4] Brackets indicates a negative SEV. Schedule shown minimizes losses.
[5]Indicates no operation conducted.

Table 42. Volume removed from the financially optimal schedules for yellow birch plantations by soil productivity and real alternative rates of return in the Northeast United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
60	2.50%	**90**[3]	-[5]	-	-	-	2,465.00	0	2,465.00	0
	5.00%	**90**	-	-	-	-	2,465.00	0	2,465.00	0
	7.50%	<**90**>[4]	-	-	-	-	2,465.00	0	2,465.00	0
	10.00%	<**90**>	-	-	-	-	2,465.00	0	2,465.00	0
	12.50%	<**90**>	-	-	-	-	2,465.00	0	2,465.00	0
	15.00%	<**90**>	-	-	-	-	2,465.00	0	2,465.00	0
70	2.50%	**89**	-	-	-	-	3,110.69	0	3,110.69	0
	5.00%	**90**	-	-	-	-	3,108.22	0	3,108.22	0
	7.50%	**90**	-	-	-	-	3,108.22	0	3,108.22	0
	10.00%	<**90**>	-	-	-	-	3,108.22	0	3,108.22	0
	12.50%	<**90**>	-	-	-	-	3,108.22	0	3,108.22	0
	15.00%	<**90**>	-	-	-	-	3,108.22	0	3,108.22	0
80	2.50%	**89**	-	-	-	-	3,336.29	0	3,336.29	0
	5.00%	**90**	-	-	-	-	3,365.85	0	3,365.85	0
	7.50%	**90**	-	-	-	-	3,365.85	0	3,365.85	0
	10.00%	**90**	-	-	-	-	3,365.85	0	3,365.85	0
	12.50%	<**90**>	-	-	-	-	3,365.85	0	3,365.85	0
	15.0%	<**90**>	-	-	-	-	3,365.85	0	3,365.85	0

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4] Brackets indicates a negative SEV. Schedule shown minimizes losses.
[5]Indicates no operation conducted.

Table 43. Financially optimal thinning and final harvest schedules for yellow birch plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	60	<81-**89**[2] >[3] (30%)[4]	<82-**89** >(25%)	0%	**90**	1%	**90**	1%
	70	<49-69-**89**> (30%)	<49-78-**89**> (30%)	0%	**89**	0%	**89**	0%
	80	<**89**>	<**89**>	0%	**89**	0%	**89**	0%
5.00%	60	<81-**90**> (30%)	<**90**>	0%	**90**	0%	**90**	0%
	70	<46-69-**90**> (30%)	<**90**>	0%	**90**	0%	**90**	0%
	80	<**89**>	<**90**>	1%	**90**	1%	**90**	1%
7.50%	60	<78-**90**> (30%)	<**90**>	0%	<**90**>	0%	<**90**>	0%
	70	<46-69-**90**> (30%)	<**90**>	0%	<**90**>	0%	**90**	0%
	80	<**89**>	<**90**>	1%	**90**	1%	**90**	1%
10.00%	60	<81-**90**> (25%)	<**90**>	0%	<**90**>	0%	<**90**>	0%
	70	<46-69-**90**> (30%)	<85-**90**> (25%)	0%	<**90**>	0%	<**90**>	0%
	80	<**90**>	<**90**>	0%	<**90**>	0%	**90**	0%
12.50%	60	<**90**>	<**90**>	0%	<**90**>	0%	<**90**>	0%
	70	<46-69-**90**> (30%)	<**90**>	0%	<**90**>	0%	<**90**>	0%
	80	<**90**>	<**90**>	0%	<**90**>	0%	<**90**>	0%
15.00%	60	<**90**>	<**90**>	0%	<**90**>	0%	<**90**>	0%
	70	<46-**89**> (30%)	<**90**>	1%	<**90**>	1%	<**90**>	1%
	80	<**90**>	<**90**>	0%	<**90**>	0%	<**90**>	0%

[1]Base age 50.

[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).

[3]<> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

[4]Number in parentheses indicates the percentage of basal area removed during thinning

Table 44. The soil expectation value ($/acre) of the financially optimal rotations for yellow birch plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI	SEVtp	SEVtc	Gain	SEVtc	Gain	SEVtc	Gain
2.50%	60	-537.35	-310.46		307.59		605.15	
	70	-522.87	-275.97		413.01		745.65	
	80	-458.65	-176.43		585.55		952.43	
5.00%	60	-482.09	-345.68		23.48		201.23	
	70	-477.88	-326.86		91.78		293.35	
	80	-415.49	-243.12		222.40		446.54	
7.50%	60	-471.56	-377.44		-123.16		-0.73	
	70	-470.20	-363.77		-72.71		67.42	
	80	-406.05	-285.30		40.74		197.72	
10.00%	60	-467.69	-397.79		-209.05		-118.17	
	70	-467.23	-363.79		-170.00		-65.41	
	80	-402.28	-311.63		-66.89		50.95	
12.50%	60	-465.64	-411.05		-263.66		-192.70	
	70	-465.48	-402.63		-232.50		-150.59	
	80	-400.24	-328.96		-136.51		-43.84	
15.00%	60	-464.37	-420.16		-300.80		-243.33	
	70	-464.31	-413.28		-275.36		-208.95	
	80	-398.97	-341.02		-184.55		-109.21	

[1]Base age 50.

[2]Gain = (SEVtc-SEVtp)/SEVtp.

Northeast- Yellow birch - Timber Only Rotations (C = $0/ton)

Yellow birch, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 81 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 27). This optimal management regime will generate the maximum SEV of -$537.35 (Table 35), with a NPW of -$479.12 per acre (Table 31). This means that -$537.35 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$479.12 per acre for managing one rotation, or -$537.35 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,477.89 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 23.94 net tons of carbon per acre during one rotation (Table 23). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Yellow birch, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 81 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 27). This optimal management regime will generate the maximum SEV of -$482.09 (Table 35), with a NPW of -$476.40 per acre (Table 31). This financially optimal rotation would

produce an estimated 2,494.45 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 23.92 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 78 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 27). This optimal management regime will generate the maximum SEV of -$471.56 (Table 35), with a NPW of -$470.91 per acre (Table 31). This financially optimal rotation would produce an estimated 2,375.19 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 24.47 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 81 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 27). This optimal management regime will generate the maximum SEV of -$467.69 (Table 35), with a NPW of -$467.61 per acre (Table 31). This financially optimal rotation would produce an estimated 2,485.99 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 24.02 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 27). This optimal management regime will generate the maximum SEV of -$465.64 (Table 35), with a NPW of -$465.63 per acre (Table 31). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 24.07 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 27). This optimal management regime will generate the maximum SEV of -$464.37 (Table 35), with a NPW of -$464.37 per acre (Table 31). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 24.07 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 49 and 69 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 27). This optimal management regime will generate the maximum SEV of -$522.87 (Table 35), with a NPW of -$466.21 per acre (Table 31). This financially optimal rotation would produce an estimated 3,202.21 cubic feet of pulpwood and 0.00 MBF of

sawlogs per acre from the thinning and final harvest (Table 39), and sequester 28.53 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 69 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 27). This optimal management regime will generate the maximum SEV of -$477.88 (Table 35), with a NPW of -$472.24 per acre (Table 31). This financially optimal rotation would produce an estimated 3,131.07 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 27.83 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 69 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 27). This optimal management regime will generate the maximum SEV of -$470.20 (Table 35), with a NPW of -$469.54 per acre (Table 31). This financially optimal rotation would produce an estimated 3,131.07 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 27.83 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 69 (with 30

percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 27). This optimal management regime will generate the maximum SEV of -$467.23 (Table 35), with a NPW of -$467.15 per acre (Table 31). This financially optimal rotation would produce an estimated 3,131.07 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 27.83 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 46 and 69 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 27). This optimal management regime will generate the maximum SEV of -$465.48 (Table 35), with a NPW of -$465.47 per acre (Table 31). This financially optimal rotation would produce an estimated 3,131.07 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 27.83 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 46 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 27). This optimal management regime will generate the maximum SEV of -$464.31 (Table 35), with a NPW of -$464.31 per acre (Table 31). This financially optimal rotation would produce an estimated 3,146.29 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre

from the thinning and final harvest (Table 39), and sequester 27.31 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 27). This optimal management regime will generate the maximum SEV of -$458.65 (Table 35), with a NPW of -$408.95 per acre (Table 31). This financially optimal rotation would produce an estimated 3,336.29 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 28.81 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 27). This optimal management regime will generate the maximum SEV of -$415.49 (Table 35), with a NPW of -$410.34 per acre (Table 31). This financially optimal rotation would produce an estimated 3,336.29 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 28.81 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 27). This optimal management regime will generate the maximum SEV of -$406.05 (Table 35), with a NPW of -$405.44 per acre (Table 31). This financially optimal rotation would

produce an estimated 3,336.29 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 28.81 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 27). This optimal management regime will generate the maximum SEV of -$402.28 (Table 35), with a NPW of -$402.21 per acre (Table 31). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 28.78 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 27). This optimal management regime will generate the maximum SEV of -$400.24 (Table 35), with a NPW of -$400.23 per acre (Table 31). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 28.78 net tons of carbon per acre during one rotation (Table 23).

Yellow birch, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 27). This optimal management regime will generate the maximum SEV of -$398.97 (Table 35),

with a NPW of -$398.97 per acre (Table31). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 39), and sequester 28.78 net tons of carbon per acre during one rotation (Table 23).

Northeast- Yellow birch - Timber Only Rotations (C = $10/ton)

Yellow birch, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a thinning is conducted at stand age 82 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 28). This optimal management regime will generate the maximum SEV of -$310.46 (Table 36), with a NPW of -$276.82 per acre (Table 32). This means that -$310.46 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus -$276.82 per acre for managing one rotation, or -$310.46 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,471.87 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 24.03 net tons of carbon per acre during one rotation (Table 24). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Yellow birch, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$345.68 (Table 36), with a NPW of -$341.60 per acre (Table 32). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 24.07 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$377.44 (Table 36), with a NPW of -$376.92 per acre (Table 32). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 24.07 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$397.79 (Table 36), with a NPW of -$397.73 per acre (Table 32). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 24.07 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$411.05 (Table 36), with a NPW of -$411.04 per acre (Table 32). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 24.07 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$420.16 (Table 36), with a NPW of -$420.16 per acre (Table 32). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 24.07 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 49 and 78 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 89 (Table 28). This optimal management regime will generate the maximum SEV of -$275.97 (Table 36), with a NPW of -$246.07 per acre (Table 32). This financially optimal rotation would produce an estimated 3,279.00 cubic feet of pulpwood and 0.00 MBF of

sawlogs per acre from the thinning and final harvest (Table 40), and sequester 28.42 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$326.86 (Table 36), with a NPW of -$323.00 per acre (Table 32). This financially optimal rotation would produce an estimated 3,108.22 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 25.87 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$363.77 (Table 36), with a NPW of -$363.26 per acre (Table 32). This financially optimal rotation would produce an estimated 3,108.22 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 25.87 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 85 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$363.79 (Table 36),

with a NPW of -$363.29 per acre (Table 32). This financially optimal rotation would produce an estimated 3,024.27 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 26.02 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$402.63 (Table 36), with a NPW of -$402.62 per acre (Table 32). This financially optimal rotation would produce an estimated 3,108.22 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 25.87 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$413.28 (Table 36), with a NPW of -$413.28 per acre (Table 32). This financially optimal rotation would produce an estimated 3,108.22 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 25.87 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 28). This

optimal management regime will generate the maximum SEV of -$176.43 (Table 36), with a NPW of -$157.31 per acre (Table 32). This financially optimal rotation would produce an estimated 3,336.29 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 28.81 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$243.12 (Table 36), with a NPW of -$240.25 per acre (Table 32). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 28.78 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$285.30 (Table 36), with a NPW of -$284.90 per acre (Table 32). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 28.78 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$311.63 (Table 36), with a NPW of -$311.58 per acre (Table 32). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 28.78 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$328.96 (Table 36), with a NPW of -$328.95 per acre (Table 32). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 28.78 net tons of carbon per acre during one rotation (Table 24).

Yellow birch, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 28). This optimal management regime will generate the maximum SEV of -$341.02 (Table 36), with a NPW of -$341.01 per acre (Table 32). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 40), and sequester 28.78 net tons of carbon per acre during one rotation (Table 24).

Northeast-Yellow birch - Timber Only Rotations (C = $37/ton)

Yellow birch, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of $307.59 (Table 37), with a NPW of $275.07 per acre (Table 33). This means that $307.59 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $275.07 per acre for managing one rotation, or $307.59 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 24.07 net tons of carbon per acre during one rotation (Table 25). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Yellow birch, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of $23.48 (Table 37), with a NPW of $23.21 per acre (Table 33). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the

thinning and final harvest (Table 41), and sequester 24.07 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$123.16 (Table 37), with a NPW of -$122.99 per acre (Table 33). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 24.07 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$209.05 (Table 37), with a NPW of -$209.01 per acre (Table 33). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 24.07 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$263.66 (Table 37), with a NPW of -$263.66 per acre (Table 133). This financially optimal rotation would

produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 24.07 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$300.80 (Table 37), with a NPW of -$300.80 per acre (Table 33). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 24.07 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 29). This optimal management regime will generate the maximum SEV of $413.01 (Table 37), with a NPW of $368.26 per acre (Table 33). This financially optimal rotation would produce an estimated 3,110.69 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 26.13 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of $91.78 (Table 37), with a NPW of $90.70 per acre (Table 33). This financially optimal rotation would produce an estimated 3,108.22 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 25.87 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$72.71 (Table 37), with a NPW of -$72.61 per acre (Table 33). This financially optimal rotation would produce an estimated 3,108.22 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 25.87 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$170.00 (Table 37), with a NPW of -$169.97 per acre (Table 33). This financially optimal rotation would produce an estimated 3,108.22 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 25.87 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This

optimal management regime will generate the maximum SEV of -$232.50 (Table 37), with a NPW of -$232.50 per acre (Table 33). This financially optimal rotation would produce an estimated 3,108.22 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 25.87 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$275.36 (Table 37), with a NPW of -$275.36 per acre (Table 33). This financially optimal rotation would produce an estimated 3,108.22 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 25.87 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 29). This optimal management regime will generate the maximum SEV of $585.55 (Table 37), with a NPW of $522.10 per acre (Table 33). This financially optimal rotation would produce an estimated 3,336.29 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 28.81 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of $222.40 (Table 37), with a NPW of $219.78 per acre (Table 33). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 28.78 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of $40.74 (Table 37), with a NPW of $40.68 per acre (Table 33). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 28.78 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$66.89 (Table 37), with a NPW of -$66.88 per acre (Table 33). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 28.78 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$136.51 (Table 37), with a NPW of -$136.50 per acre (Table 33). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 28.78 net tons of carbon per acre during one rotation (Table 25).

Yellow birch, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 29). This optimal management regime will generate the maximum SEV of -$184.55 (Table 37), with a NPW of -$184.55 per acre (Table 33). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 41), and sequester 28.78 net tons of carbon per acre during one rotation (Table 25).

Northwest- Yellow birch - Timber Only Rotations (C = $50/ton)

Yellow birch, Site Index 60 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $605.15 (Table 38), with a NPW of $541.18 per acre (Table 34). This means that $605.15 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 60 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $541.18 per acre for managing one rotation, or $605.15 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 24.07 net tons of carbon per acre during one rotation (Table 26). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Yellow birch, Site Index 60 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $201.23 (Table 38), with a NPW of $198.85 per acre (Table 34). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 24.07 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 60 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$0.73 (Table 38), with a NPW of -$0.73 per acre (Table 34). This financially optimal rotation would produce an

estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 24.07 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 60 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$118.17 (Table 38), with a NPW of -$118.15 per acre (Table 34). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 24.07 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 60 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$192.70 (Table 38), with a NPW of -$192.69 per acre (Table 34). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 24.07 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 60 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$243.33 (Table 38),

with a NPW of -$243.33 per acre (Table 34). This financially optimal rotation would produce an estimated 2,465.00 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 24.07 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 70 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 30). This optimal management regime will generate the maximum SEV of $745.65 (Table 38), with a NPW of $664.85 per acre (Table 34). This financially optimal rotation would produce an estimated 3,110.69 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 26.13 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 70 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $293.35 (Table 38), with a NPW of $289.89 per acre (Table 34). This financially optimal rotation would produce an estimated 3,108.22 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 25.87 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 70 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This

optimal management regime will generate the maximum SEV of $67.42 (Table 38), with a NPW of $67.33 per acre (Table 34). This financially optimal rotation would produce an estimated 3,108.22 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 25.87 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 70 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$65.41 (Table 38), with a NPW of -$65.39 per acre (Table 34). This financially optimal rotation would produce an estimated 3,108.22 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 25.87 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 70 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$150.59 (Table 38), with a NPW of -$150.59 per acre (Table 34). This financially optimal rotation would produce an estimated 3,108.22 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 25.87 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 70 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 3). This optimal management regime will generate the maximum SEV of -$208.95 (Table 38), with a NPW of -$208.95 per acre (Table 34). This financially optimal rotation would produce an estimated 3,108.22 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 25.87 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 80 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 89 (Table 30). This optimal management regime will generate the maximum SEV of $952.43 (Table 38), with a NPW of $849.23 per acre (Table 34). This financially optimal rotation would produce an estimated 3,336.29 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 28.81 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 80 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $446.54 (Table 38), with a NPW of $441.28 per acre (Table 34). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 28.78 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 80 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $197.72 (Table 38), with a NPW of $197.44 per acre (Table 34). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 28.78 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 80 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of $50.95 (Table 38), with a NPW of $50.94 per acre (Table 34). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 28.78 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 80 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$43.84 (Table 38), with a NPW of -$43.84 per acre (Table 34). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the

thinning and final harvest (Table 42), and sequester 28.78 net tons of carbon per acre during one rotation (Table 26).

Yellow birch, Site Index 80 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a final harvest is conducted at stand age 90 (Table 30). This optimal management regime will generate the maximum SEV of -$109.21 (Table 38), with a NPW of -$109.21 per acre (Table 34). This financially optimal rotation would produce an estimated 3,365.85 cubic feet of pulpwood and 0.00 MBF of sawlogs per acre from the thinning and final harvest (Table 42), and sequester 28.78 net tons of carbon per acre during one rotation (Table 26).

Yellow poplar (*Liriodendron tulipifera*)

Biological Information

Yellow poplar is one of the largest and most aesthetically pleasing of the eastern hardwoods. It is common on deep well-drained soils, and may reach ages of up to 300 years. The range of yellow-poplar extends throughout the eastern United States from north-central Florida, east to south Louisiana, north to Michigan, then east to southern New England (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/liriodendron/tulipifera.htm. April 26, 2006) (Fig. 1).

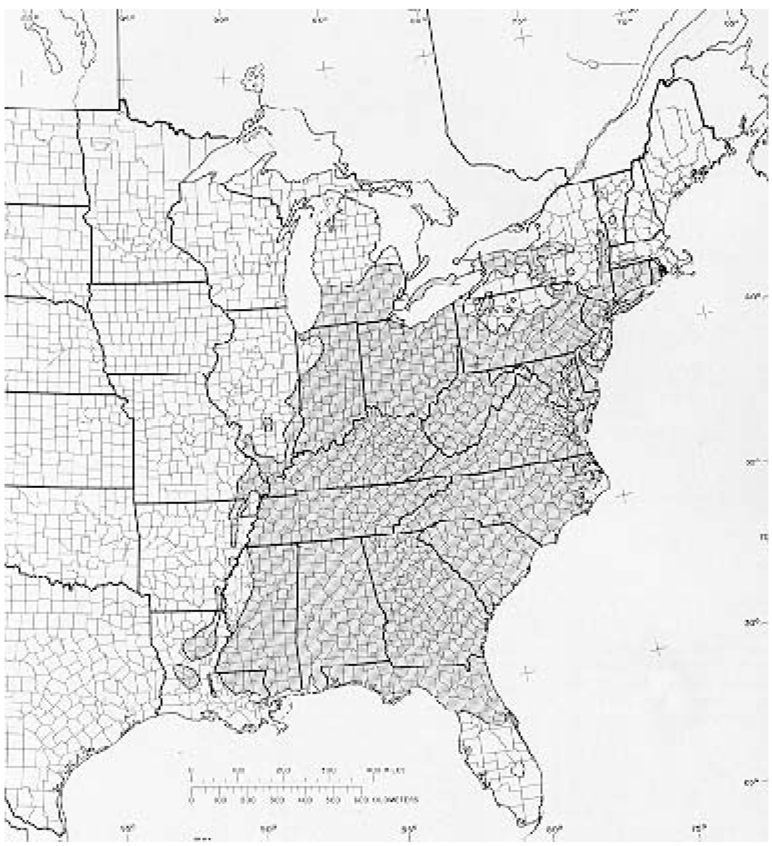

Fig. 1. The native range of yellow poplar (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/liriodendron/tulipifera.htm. April 26, 2006)

Yellow-poplar reaches its greatest size in the Ohio River valley and the slopes of Kentucky, Tennessee, West Virginia, and North Carolina. The area containing the Appalachian Mountains and Piedmont running from Georgia to Pennsylvania contained 75% of yellow-poplar stock in 1974 (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/liriodendron/tulipifera.htm. April 26, 2006).

Yellow-poplar at maturity can reach up to 200 feet in height with a d.b.h. of 8 to 12 feet. More commonly height range is from 100 to 150 feet with a d.b.h. of 2 to 5 feet. Site indices ranging from 75 to 125 feet on base age 50 curves are not uncommon. In forest conditions it produces a long, clear, very straight bole with a high crown. Fully stocked stands exhibit excellent self-pruning. The maximum attainable age is approximately 300 years. Typically mean annual increment culminates at around 70 years of age, with MAI in total cubic volume ranging from 75 to 165 ft^3/acre, depending on site index. Stands reach pole size at between 20 and 30 years of age. At this point the peaks of growth rate and mortality are past and the canopy closed (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/liriodendron/tulipifera.htm. April 26, 2006).

Yellow-poplar is classified as intolerant of shade, but because of its rapid growth it can overcome competition in young dense stands. Starting at site index 75 ft. in the southern Appalachians only white pine produces greater height growth than yellow-poplar before age 50. Like other hardwood species it will produce epicormic sprouts on the bole, but not as prolifically as many other species. Intermediate and even overtopped trees with good vigor respond well in both diameter and height growth to release.

(USDA Forest Service.
http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/liriodendron/tulipifera.htm. April 26, 2006).

Yellow-poplar is a versatile wood and has been utilized for a variety of uses. It has been used in the furniture industry for unexposed parts, core stock, veneer, plywood, and pulpwood. More recently it has been used as structural framing material, and veneers to replace scarce softwoods. Yellow-poplar also makes an excellent ornamental tree due to its distinctive flowers, leaves, and overall pleasing appearance (USDA Forest Service. http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/liriodendron/tulipifera.htm. April 26, 2006).

Economic Background

Blinn et al. (1986) performed a financial analysis to determine the feasibility of installing a yellow-poplar oriented strandboard (OSB) plant near Elkins, West Virginia. At the time of this study the use of yellow-poplar had been declining, and ways were being sought to increase utilization of the species. Yellow-poplar produces a low density wood; such wood is commonly used in the construction of OSB. Elkins was chosen because OSB markets (300-500 mile radius) and local supplies of timber (75 mile radius) were both high. Blinn determined that the after-tax net present value of such a facility would be $1.8 million over an 18-year investment period, using a 49% tax rate and 14% discount rate. In this scenario the proposed facility would only need to capture less than 5% of the local market to sell all it produced. They concluded that with the assumptions made holding true, an OSB plant using yellow-poplar near Elkins West Virginia would be feasible.

Smith (1973) conducted an economic analysis to determine raw material prices required to make growing hardwoods economical. The analysis used a range of interest rates, establishment costs, and harvest values to determine; optimal rotation length (financial maturity), maximum soil expectation value (SEV), and net present value. Smith found that hardwood plantations could be economically justified in 1973. The data indicate that if establishment costs were $100 or less, and the interest rate was 6%, then yellow-poplar became profitable at about $0.16/ cubic foot.

Holsoe (1950) studies the effect of various thinning operations on the growth and lumber grade development obtained from yellow-poplar trees of different forms. The objective was to develop trees so that they reach their optimum value in the shortest possible time. Yellow-poplar is one of the fastest growing timber species in the Appalachians and responds well to intensive management practices. Holsoe determined that the aim should be to maintain dense stands until two clear 16-foot logs had been developed since the first two logs are worth considerably more than any further logs (first log = $36, second log = $27.50, third log = $23.75, fourth log = $22.00). After this point (through repeated thinnings), trees with a total height of 100 feet and crown lengths of 60 feet will be possible. Trees managed in this manner will show a much faster growth rate and reach merchantable sizes in a much shorter time.

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Species yellow poplar Region South

Site indices 90, 100 and 110 (base age 50), the range of site indices most commonly observed, were used in the analyses. Sawlog volume was measured in Scribner to a 9-in. inside bark top diameter for trees with a minimum of 12 in. diameter at breast height (dbh). Pulpwood volume was measured in cubic feet to a 4-in. inside bark top diameter for trees in the 6- to 11-in. dbh classes. The maximum possible rotation length was limited to age 60 with a choice of up to 2 thinnings during the rotation. The first thinning could not be conducted until the stand was at least 20 years of age. The minimum number of years between thinnings, or between a thinning and the final harvest, could not be less than 5. For all computer simulations, a "thinning and final harvest" regime was considered operable only if it passed the following two threshold constraints: 1) every thinning or final harvest had to yield a minimum of 552 cubic-foot volume of pulpwood and/or sawtimber per acre; 2) the number of residual trees after each thinning had to be at least 80 per acre. Three thinning intensities were employed: 25, 30 and 35% of basal area removal.

The factors used to convert above-ground biomass to total tree biomass and merchantable tree biomass were 1.245225694 and 0.434027778, respectively (Birdsey 1996). The net amount of carbon in trees was estimated to be 50% of dry biomass. Other components of forest ecosystems (i.e. soil, litter layer, and understory vegetation) were not included in the analyses. Dry weight equations developed by Clark et al. (1986) were used to calculate the amount of dry weight biomass in the aboveground portion of trees. The equations were:

$$Yp = 0.03353(D^2H)^{1.07770}$$

$$Ys = 0.17805(D^2)^{0.072957}(H)^{1.07770}$$

where:

Yp = dry-weight (lbs.) of stemwood and bark of trees < 11.0 in. d.b.h

Ys = dry-weight (lbs.) of stemwood and bark of trees $\geq$ 11.0 in d.b.h

D = diameter at breast height (in.)

H = total height (ft.)

Six real alternative rates of return (ARR) of 2.5%, 5.0%, 7.5%, 10.0%, 12.5% and 15.0% were chosen for the economic analyses. In this study, it was assumed that NIPF landowners would receive timber revenues only from pulpwood and sawtimber sales; therefore, only these two products were taken into consideration for economic evaluation. The annual real rates of price increase for sawtimber and pulpwood were assumed to be 1.6% and 1.24% (Haynes 2003), respectively. The annual real rate of cost increase for labor and non-labor activities was assumed to be 0.47% (Council of Economic Advisers 2005). The price of sawtimber was assumed to be $196/mbf (Scribner) (Timber Mart South, Inc. 2000-2005) and pulpwood price was assumed to be $16.44/cord (Timber Mart South, Inc. 2000-2005). The price of carbon was assumed to be $0, $10, $37 or $50 for each additional ton of carbon that landowners were able to sequester.

Assorted management activities, costs and frequencies for economic analysis of yellow poplar plantations in the South.

Activity	Cost ($/ac)	Frequency	Start	End
Management plans (initial)	$5.00	Only once	Year 0	
Management plans (updates)	$10.00	Every 10 years	Year 10	Final Harvest
Site preparation (chop)[a]	$91.41	Only once	Year 0	
Site preparation (herbicide)[a]	$86.46	Only once	Year 0	
Hand planting, labor[a]	$60.00	Only once	Year 0	
Seedlings[b] (436 seedlings/ac)	$152.60	Only Once	Year 0	
Thinning & final harvest costs	10% of Revenues	As necessary		

[a]Data from Smidt et al. (2005).

[b]Data from Hans M. Williams, personal communication, Stephen F. Austin State University, December 19, 2006.

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Table 1. Total tons of carbon sequestered per acre for yellow poplar plantations in the southern United States by site index and real alternative rates of return. (carbon value = $00/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	40.21	38.56	35.80	31.88	31.88	29.20
100	42.27	43.67	40.74	38.38	34.16	34.16
110	48.23	47.75	45.50	39.26	39.26	36.41

[1]Base age 50.

Table 2. Total tons of carbon sequestered per acre for yellow poplar plantations in the southern United States by site index and real alternative rates of return. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	40.21	40.21	38.84	36.26	31.98	31.46
100	42.84	43.29	42.65	39.74	34.16	34.16
110	48.23	47.75	45.50	45.00	41.64	39.82

[1]Base age 50.

Table 3. Total tons of carbon sequestered per acre for yellow poplar plantations in the southern United States by site index and real alternative rates of return. (carbon value = $37/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	39.57	39.57	38.84	24.28	24.56	24.45
100	44.69	44.69	42.65	41.84	41.10	40.34
110	48.23	50.13	47.14	46.73	46.73	43.74

[1]Base age 50.

Table 4. Total tons of carbon sequestered per acre for yellow poplar plantations in the southern United States by site index and real alternative rates of return. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	39.57	39.57	38.84	38.84	38.84	25.00
100	44.69	44.69	46.16	41.84	41.84	40.25
110	48.23	50.13	47.77	47.77	46.73	47.39

[1]Base age 50.

Table 5. Financially optimal thinning and final harvest schedules which maximize soil expectation value for yellow poplar plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	33-44-**60**[2] (30%)[3]	33-39-**59** (30%)	<29-34-**56**>[4] (30%)	<29-36-**52**> (35%)	<29-36-**52**> (35%)	<29-35-**48**> (35%)
100	27-33-**60** (30%)	29-38-**59** (30%)	<28-33-**55>** (30%)	<27-32-**52>** (30%)	<28-33-**48** (35%)	**<28-33**-48> **(35%)**
110	26-31-**60** (25%)	26-31-**59** (25%)	<28-34-**53**> (30%)	<25-33-**49**> (35%)	<25-33-**49**> (35%)	<25-31-**46**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 6. Financially optimal thinning and final harvest schedules which maximize soil expectation value for yellow poplar plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	33-44-**60**[2] (30%)[3]	33-44-**60** (30%)	<37-45-**57**>[4] (25%)	<30-41-**54**> (30%)	<29-39-**51**> (35%)	<29-39-**50**> (35%)
100	**60**	28-42-**56** (30%)	<29-41-**55**> (30%)	<32-38-**52**> (30%)	<28-33-**48**> (35%)	<28-33-**48**> (35%)
110	26-31-**60** (25%)	26-31-**59** (25%)	<28-34-**53**> (30%)	<27-35-**52**> (30%)	<28-35-**48**> (30%)	<27-35-**48**> (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 7. Financially optimal thinning and final harvest schedules which maximize soil expectation value for yellow poplar plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	34-42-**60**[2] (25%)[3]	34-42-**60** (25%)	37-45-**57** (25%)	<37-**57**>[4] (25%)	<49-**57**> (25%)	<50-**55**> (25%)
100	32-40-**60** (25%)	32-40-**60** (25%)	29-41-**55** (30%)	<35-40-**53**> (25%)	<35-40-**52**> (25%)	<35-40-**51**> (35%)
110	26-31-**60** (25%)	27-**60** (25%)	27-47-**54** (25%)	34-40-**52** (25%)	<34-40-**52>** (25%)	28-38-**48** (25%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 8. Financially optimal thinning and final harvest schedules which maximize soil expectation value for yellow poplar plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	34-42-**60**[2] (25%)[3]	34-42-**60** (25%)	37-45-**57** (25%)	<37-45-**57>** (25%)	<37-45-**57>** (25%)	<50-**57>** (25%)
100	32-40-**60** (25%)	32-40-**60** (25%)	53-**58** (35%)	35-40-**53** (35%)	<35-40-**53**> (25%)	<36-44-**51**> (25%)
110	26-31-**60** (25%)	27-**60** (25%)	35-41-**54** (25%)	35-41-**54** (25%)	<34-40-**52>** (25%)	<46-**52>** (35%)

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3]Number in parentheses indicates the percentage of basal area removed during thinning(s).
[4]Brackets indicates a negative SEV. Schedule shown minimizes losses.

Table 9. Net present worth of the financially optimal thinning and final harvest schedules for yellow poplar plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$1,933.69	$166.69	-$245.42	-$352.24	-$382.51	-$391.96
100	$2,258.46	$248.82	-$217.05	-$340.62	-$376.90	-$389.46
110	$2,583.41	$328.64	-$187.36	-$327.65	-$371.80	-$386.79

[1]Base age 50.

Table 10. Net present worth of the financially optimal thinning and final harvest schedules for yellow poplar plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

	Real Alternative Rates of Return					
Site Index[1]	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,176.73	$313.20	-$155.27	-$290.11	-$337.72	-$357.79
100	$2,183.92	$419.41	-$103.29	-$262.20	-$319.79	-$344.74
110	$2,583.41	$531.01	-$55.39	-$234.99	-$301.87	-$332.06

[1]Base age 50.

Table 11. Net present worth of the financially optimal thinning and final harvest schedules for yellow poplar plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,835.11	$713.81	$101.16	-$115.62	-$209.16	-$259.04
100	$3,310.27	$907.54	$205.08	-$45.69	-$160.32	-$221.75
110	$3,761.87	$1,089.16	$305.98	$22.24	-$109.13	-$180.63

[1]Base age 50.

Table 12. Net present worth of the financially optimal thinning and final harvest schedules for yellow poplar plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$3,153.06	$907.61	$224.62	-$34.13	-$153.50	-$210.94
100	$3,682.93	$1,141.18	$357.59	$59.71	-$82.59	-$161.80
110	$4,175.93	$1,366.35	$484.74	$149.07	-$14.37	-$106.77

[1]Base age 50.

Table 13. Soil expectation value of the financially optimal thinning and final harvest schedules for yellow poplar plantations by site index and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,484.64	$176.12	-$249.47	-$354.50	-$383.25	-$392.37
100	$2,901.93	$262.90	-$220.90	-$342.81	-$378.08	-$389.88
110	$3,319.46	$347.23	-$191.21	-$330.46	-$372.84	-$387.33

[1]Base age 50.

Table 14. Soil expectation value of the financially optimal thinning and final harvest schedules for yellow poplar plantations by site index and real alternative rates of return in the southern United States. (carbon value = $10/ton)

Site Index[1]	Real Alternative Rates of Return					
	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$2,796.92	$330.03	-$157.65	-$291.66	-$338.46	-$358.08
100	$2,806.16	$447.12	-$105.12	-$263.89	-$320.79	-$345.11
110	$3,319.46	$561.04	-$56.53	-$236.51	-$302.81	-$332.41

[1]Base age 50.

Table 15. Soil expectation value of the financially optimal thinning and final harvest schedules for yellow poplar plantations by site index and real alternative rates of return in the southern United States. (carbon value = $37/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$3,642.89	$752.16	$102.71	-$116.08	-$209.39	-$259.14
100	$4,253.43	$956.30	$208.72	-$45.96	-$160.63	-$221.90
110	$4,822.69	$1,147.67	$311.82	$22.38	-$109.34	-$180.82

[1]Base age 50.

Table 16. Soil expectation value of the financially optimal thinning and final harvest schedules for yellow poplar plantations by site index and real alternative rates of return in the southern United States. (carbon value = $50/ton)

Site Index[1]	Real Alternative Rates of Return 2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
90	$4,051.42	$956.38	$228.06	-$34.27	-$153.66	-$211.01
100	$4,732.27	$1,202.50	$362.67	$60.06	-$82.73	-$161.91
110	$5,365.72	$1,439.76	$494.00	$149.86	-$14.39	-$106.84

[1]Base age 50.

Table 17. Volume removed from the financially optimal schedules for yellow poplar plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $0/ton)

Site Index[1]	ARR	Schedule	1st thinning		2nd thinning		Final Harvest		Total Volume	
			Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.50%	33-44-**60**[3] (30%)[4]	812.87	0	1,129.73	0	455.13	21.15	2,397.73	21.15
	5.00%	33-39-**59** (30%)	812.87	0	898.97	0	518.76	20.48	2,230.60	20.48
	7.50%	29-34-**56** (30%)	558.94	0	716.31	0	805.62	18.02	2,080.87	18.02
	10.00%	29-36-**52** (35%)	681.80	0	884.41	0	835.26	12.84	2,401.47	12.84
	12.50%	29-36-**52** (35%)	681.80	0	884.41	0	835.26	12.84	2,401.47	12.84
	15.00%	29-35-**48** (35%)	681.80	0	836.80	0	1407.67	7.72	2,926.27	7.72
100	2.50%	27-33-**60** (30%)	564.12	0	822.28	0	461.93	24.54	1,848.33	24.54
	5.00%	29-38-**59** (30%)	751.68	0	1049.83	0	477.73	23.46	2,279.24	23.46
	7.50%	28-33-**55** (30%)	673.70	0	816.59	0	831.85	19.89	2,322.14	19.89
	10.00%	27-32-**52** (30%)	564.12	0	775.89	0	1,173.37	16.41	2,513.38	16.41
	12.50%	28-33-**48** (35%)	815.10	0	895.33	0	1,253.40	10.77	2,963.83	10.77
	15.00%	28-33-**48** (35%)	815.10	0	895.33	0	1,253.40	10.77	2,963.83	10.77
110	2.50%	26-31-**60** (25%)	567.72	0	746.20	0	670.15	27.59	1,984.07	27.59
	5.00%	26-31-**59** (25%)	567.72	0	746.20	0	694.95	26.79	2,008.87	26.79
	7.50%	28-34-**53** (30%)	922.39	0	984.16	0	865.32	20.25	2,771.87	20.25
	10.00%	25-33-**49** (35%)	728.70	0	1,041.96	0	863.72	15.11	2,634.38	15.11
	12.50%	25-33-**49** (35%)	728.70	0	1,041.96	0	863.72	15.11	2,634.38	15.11
	15.00%	25-31-**46** (35%)	728.70	0	925.49	0	1,486.07	10.38	3,140.26	10.38

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 18. Volume removed from the financially optimal schedules for yellow poplar plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $10/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.50%	33-44-**60**[3] (30%)[4]	812.87	0	1,129.73	0	455.13	21.15	2,397.73	21.15
	5.00%	33-44-**60** (30%)	812.87	0	1,129.73	0	455.13	21.15	2,397.73	21.15
	7.50%	37-45-**57** (25%)	858.03	0	965.03	0	594.50	19.07	2,417.56	19.07
	10.00%	30-41-**54** (30%)	601.55	0	1,024.70	0	883.45	15.85	2,509.70	15.85
	12.50%	29-39-**51** (35%)	681.80	0	1,035.24	0	851.19	11.86	2,568.23	11.86
	15.00%	29-39-**50** (35%)	681.80	0	1,035.24	0	1008.27	10.54	2,725.31	10.54
100	2.50%	**60**	-[5]	-	-	-	2498.52	20.93	2,498.52	20.93
	5.00%	28-42-**56** (30%)	673.70	0	1,244.67	0	559.50	21.15	2,477.87	21.15
	7.50%	29-41-**55** (30%)	751.68	0	1,195.19	0	610.62	20.02	2,557.49	20.02
	10.00%	32-38-**52** (30%)	981.86	0	1,010.74	0	863.32	16.29	2,855.92	16.29
	12.50%	28-33-**48** (35%)	815.10	0	895.33	0	1253.40	10.77	2,963.83	10.77
	15.00%	28-33-**48** (35%)	815.10	0	895.33	0	1253.40	10.77	2,963.83	10.77
110	2.50%	26-31-**60** (25%)	567.72	0	746.20	0	670.15	27.59	1,984.07	27.59
	5.00%	26-31-**59** (25%)	567.72	0	746.20	0	694.95	26.79	2,008.87	26.79
	7.50%	28-34-**53** (30%)	922.39	0	984.16	0	865.32	20.25	2,771.87	20.25
	10.00%	27-35-**52** (30%)	836.62	0	1,052.52	0	932.20	19.11	2,821.34	19.11
	12.50%	28-35-**48** (30%)	922.39	0	1,035.80	0	1503.50	13.33	3,461.69	13.33
	15.00%	27-35-**48** (35%)	989.56	0	1,150.80	0	1133.68	12.95	3,274.04	12.95

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 19. Volume removed from the financially optimal schedules for yellow poplar plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $37/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.50%	34-42-**60**[3] (25%)[4]	727.83	0	897.08	0	623.02	21.23	2,247.93	21.23
	5.00%	34-42-**60** (25%)	727.83	0	897.08	0	623.02	21.23	2,247.93	21.23
	7.50%	37-45-**57** (25%)	858.03	0	965.03	0	594.50	19.07	2,417.56	19.07
	10.00%	37-**57** (25%)	858.03	0	-[5]	-	1,576.28	17.72	2,434.31	17.72
	12.50%	49-**57** (25%)	1,287.26	0	-	-	1,466.22	16.25	2,753.48	16.25
	15.00%	50-**55** (25%)	1,320.67	0	-	-	2,202.35	13.08	3,523.02	13.08
100	2.50%	32-40-**60** (25%)	811.78	0	970.83	0	568.07	24.19	2,350.68	24.19
	5.00%	32-40-**60** (25%)	811.78	0	970.83	0	568.07	24.19	2,350.68	24.19
	7.50%	29-41-**55** (30%)	751.68	0	1195.19	0	610.62	20.02	2,557.49	20.02
	10.00%	35-40-**53** (25%)	924.78	0	938.34	0	1,129.35	17.23	2,992.47	17.23
	12.50%	35-40-**52** (25%)	924.78	0	938.34	0	1,287.54	15.77	1,991.66	15.77
	15.00%	35-40-**51** (35%)	924.78	0	938.34	0	1,424.14	14.37	3,287.26	14.37
110	2.50%	26-31-**60** (25%)	567.72	0	746.20	0	670.15	27.59	1,984.07	27.59
	5.00%	27-**60** (25%)	685.51	0	-	-	1,586.44	27.06	2,271.95	27.06
	7.50%	27-47-**54** (25%)	685.51	0	1369.69	0	733.33	20.95	2,788.53	20.95
	10.00%	34-40-**52** (25%)	1,004.30	0	1063.17	0	1,279.64	17.88	3,347.11	17.88
	12.50%	34-40-**52** (25%)	1,004.30	0	1063.17	0	1,279.64	17.88	3,347.11	17.88
	15.00%	28-38-**48** (25%)	762.40	0	1035.75	0	2,159.86	12.28	3,958.01	12.28

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 20. Volume removed from the financially optimal schedules for yellow poplar plantations by soil productivity and real alternative rates of return in the southern United States. (carbon value = $50/ton)

			1st thinning		2nd thinning		Final Harvest		Total Volume	
Site Index[1]	ARR	Schedule	Cu. Ft.	MBF[2]	Cu. Ft.	MBF	Cu. Ft.	MBF	Cu. Ft.	MBF
90	2.50%	34-42-**60**[3] (25%)[4]	727.83	0	897.08	0	623.02	21.23	2,247.93	21.23
	5.00%	34-42-**60** (25%)	727.83	0	897.08	0	623.02	21.23	2,247.93	21.23
	7.50%	37-45-**57** (25%)	858.03	0	965.03	0	594.50	19.07	2,417.56	19.07
	10.00%	37-45-**57** (25%)	858.03	0	965.03	0	594.50	19.07	2,417.56	19.07
	12.50%	37-45-**57** (25%)	858.03	0	965.03	0	594.50	19.07	2,417.56	19.07
	15.00%	50-**57** (25%)	1320.67	0	-[5]	-	1,625.48	15.83	2,946.15	15.83
100	2.50%	32-40-**60** (25%)	811.78	0	970.83	0	568.07	24.19	2,350.68	24.19
	5.00%	32-40-**60** (25%)	811.78	0	970.83	0	568.07	24.19	2,350.68	24.19
	7.50%	53-**58** (35%)	2,306.28	0	-	-	636.17	20.78	2,942.45	20.78
	10.00%	35-40-**53** (25%)	924.78	0	938.34	0	1,129.35	17.23	2,992.47	17.23
	12.50%	35-40-**53** (25%)	924.78	0	938.34	0	1,129.35	17.23	2,992.47	17.23
	15.00%	36-44-**51** (25%)	962.32	0	1072.80	0	1,287.65	14.02	3,322.77	14.02
110	2.50%	26-31-**60** (25%)	567.72	0	746.20	0	670.15	27.59	1,984.07	27.59
	5.00%	27-**60** (25%)	685.51	0	-	-	1,586.44	27.06	2,271.95	27.06
	7.50%	35-41-**54** (25%)	1,044.61	0	1086.04	0	882.76	20.55	3,013.77	20.55
	10.00%	35-41-**54** (25%)	1,044.61	0	1086.40	0	882.76	20.55	3,013.77	20.55
	12.50%	34-40-**52** (25%)	1,004.30	0	1063.17	0	1,279.64	17.88	3,347.11	17.88
	15.0%	46-**52** (35%)	2,136.83	0	-	-	1,710.02	15.54	3,846.85	15.54

[1]Base age 50.
[2]Thousand board feet (Scribner).
[3]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[4]Number in parentheses indicates the percentage of basal area removed during thinning (s).
[5]Indicates no operation conducted.

Table 21. Financially optimal thinning and final harvest schedules for yellow poplar plantations managed exclusively for timber production (C=$0/ton) or for timber production and carbon sequestration (C=$10, 37 or 50/ton).

ARR	SI[1]	C=$0/ton	C=$10/ton	ΔR	C=$37/ton	ΔR	C=$50/ton	ΔR
2.50%	90	33-44-**60**[2] (30%)[3]	33-44-**60** (30%)	0%	34-42-**60** (25%)	0%	34-42-**60** (25%)	0%
	100	27-33-**60** (30%)	**60**	0%	32-40-**60** (25%)	0%	32-40-**60** (25%)	0%
	110	26-31-**60** (25%)	26-31-**60** (25%)	0%	26-31-**60** (25%)	0%	26-31-**60** (25%)	0%
5.00%	90	33-39-**59** (30%)	33-44-**60** (30%)	2%	34-42-**60** (25%)	2%	34-42-**60** (25%)	2%
	100	29-38-**59** (30%)	28-42-**56** (30%)	-5%	32-40-**60** (25%)	2%	32-40-**60** (25%)	2%
	110	26-31-**59** (25%)	26-31-**59** (25%)	0%	27-**60** (25%)	2%	27-**60** (25%)	2%
7.50%	90	<29-34-**56**>[4] (30%)	<37-45-**57**> (25%)	2%	37-45-**57** (25%)	2%	37-45-**57** (25%)	2%
	100	<28-33-**55**> (30%)	<29-41-**55**> (30%)	0%	29-41-**55** (30%)	0%	53-**58** (35%)	5%
	110	<28-34-**53**> (30%)	<28-34-**53**> (30%)	0%	27-47-**54** (25%)	2%	35-41-**54** (25%)	2%
10.00%	90	<29-36-**52**> (35%)	<30-41-**54**> (30%)	4%	<37-**57**> (25%)	10%	<37-45-**57**> (25%)	10%
	100	<27-32-**52**> (30%)	<32-38-**52**> (30%)	0%	<35-40-**53**> (25%)	2%	35-40-**53** (35%)	2%
	110	<25-33-**49**> (35%)	<27-35-**52**> (30%)	6%	34-40-**52** (25%)	6%	35-41-**54** (25%)	10%
12.50%	90	<29-36-**52**> (35%)	<29-39-**51**> (35%)	-2%	<49-**57**> (25%)	10%	<37-45-**57**> (25%)	10%
	100	<28-33-**48** (35%)	<28-33-**48**> (35%)	0%	<35-40-**52**> (25%)	8%	<35-40-**53**> (25%)	10%
	110	<25-33-**49**> (35%)	<28-35-**48**> (30%)	-2%	<34-40-**52**> (25%)	6%	<34-40-**52**> (25%)	6%
15.00%	90	<29-35-**48**> (35%)	<29-39-**50**> (35%)	4%	<50-**55**> (25%)	15%	<50-**57**> (25%)	19%
	100	<28-33-**48**> (35%)	<28-33-**48**> (35%)	0%	<35-40-**51**> (35%)	6%	<36-44-**51**> (25%)	6%
	110	<25-31-**46**> (35%)	<27-35-**48**> (35%)	4%	28-38-**48** (25%)	4%	<46-**52**> (35%)	13%

[1]Base age 50.
[2]Bold type indicates the age of final harvest, and the number(s) to the left indicates age(s) at thinning(s).
[3] Number in parentheses indicates the percentage of basal area removed during thinning.
[4] <> indicates a negative SEVtp or SEVtc. Schedules shown minimize losses.

Table 22. The soil expectation value ($/acre) of the financially optimal rotations for yellow poplar plantations managed exclusively for timber production (SEVtp) or for joint timber production and carbon sequestration (SEVtc).

		C=$0/ton	C=$10/ton		C=$37/ton		C=$50/ton	
ARR	SI[1]	SEVtp	SEVtc	Gain[2]	SEVtc	Gain	SEVtc	Gain
2.50%	90	2,484.64	2,796.92	13%	3,642.89	47%	4,051.42	63%
	100	2,901.93	2,806.16		4,253.43	47%	4,732.27	63%
	110	3,319.46	3,319.46	0%	4,833.69	46%	5,365.72	62%
5.00%	90	176.12	330.03	87%	752.16	327%	956.38	443%
	100	262.90	447.12	70%	956.30	264%	1,202.50	357%
	110	347.23	561.04	62%	1,147.67	231%	1,439.76	315%
7.50%	90	-249.47	-157.65		102.71		228.06	
	100	-220.90	-105.12		208.72		362.67	
	110	-191.21	-56.53		311.82		494.00	
10.00%	90	-354.50	-291.66		-116.08		-34.27	
	100	-342.81	-263.89		-45.96		60.06	
	110	-330.46	-236.51		22.38		149.86	
12.50%	90	-383.25	-338.46		-209.39		-153.66	
	100	-378.08	-320.79		-160.63		-82.73	
	110	-372.84	-302.81		-109.34		-14.39	
15.00%	90	-392.37	-358.08		-259.14		-211.01	
	100	-389.88	-345.11		-221.90		-161.91	
	110	-387.33	-332.41		-180.82		-106.84	

[1]Base age 50.
[2]Gain = (SEVtc-SEVtp)/SEVtp.

Southern- Yellow poplar - Timber Only Rotations (C = $0/ton)

Yellow poplar, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of $2,484.64 (Table 13), with a NPW of $1,933.69 per acre (Table 9). This means that $2,484.64 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 90 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $1,933.69 per acre for managing one rotation, or $2,484.64 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,397.73 cubic feet of pulpwood and 21.15 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 40.21 net tons of carbon per acre during one rotation (Table 1). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Yellow poplar, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 39 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 5). This optimal management regime will generate the maximum SEV of $176.12 (Table 13), with a NPW of $166.69 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,230.60 cubic feet of pulpwood and 20.48 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 38.56 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 5). This optimal management regime will generate the maximum SEV of -$249.47 (Table 13), with a NPW of -$245.42 per acre (Table 9). This financially optimal rotation would produce an estimated 2,080.87 cubic feet of pulpwood and 18.02 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 35.80 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 36 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 5). This optimal management regime will generate the maximum SEV of -$354.50 (Table 13), with a NPW of -$352.24 per acre (Table 9). This financially optimal rotation would produce an estimated 2,401.47 cubic feet of pulpwood and 12.84 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 31.88 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 36 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 5). This optimal management regime will generate the maximum SEV of -$383.25 (Table 13), with a NPW of -$382.51 per acre (Table 9). This financially optimal rotation would produce an estimated 2,401.47 cubic feet of pulpwood and 12.84 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 31.88 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 35 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 48 (Table 5). This optimal management regime will generate the maximum SEV of -$392.37 (Table 13), with a NPW of -$391.96 per acre (Table 9). This financially optimal rotation would produce an estimated 2,926.27 cubic feet of pulpwood and 7.72 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 29.20 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 33 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of $2,901.93 (Table 13), with a NPW of $2,258.46 per acre (Table 9). This financially optimal rotation would

produce an estimated 1,848.33 cubic feet of pulpwood and 24.54 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 42.27 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 38 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 5). This optimal management regime will generate the maximum SEV of $262.90 (Table 13), with a NPW of $248.82 per acre (Table 9). This financially optimal rotation would produce an estimated 2,279.24 cubic feet of pulpwood and 23.46 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 43.67 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 28 and 33 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 5). This optimal management regime will generate the maximum SEV of -$220.90 (Table 13), with a NPW of -$217.05 per acre (Table 9). This financially optimal rotation would produce an estimated 2,322.14 cubic feet of pulpwood and 19.89 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 40.74 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 32 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 5). This optimal management regime will generate the maximum SEV of -$342.81 (Table 13), with a NPW of -$340.62 per acre (Table 9). This financially optimal rotation would produce an estimated 2,513.38 cubic feet of pulpwood and 16.41 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 38.38 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 28 and 33 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 48 (Table 5). This optimal management regime will generate the maximum SEV of -$378.08 (Table 13), with a NPW of -$376.90 per acre (Table 9). This financially optimal rotation would produce an estimated 2,963.83 cubic feet of pulpwood and 10.77 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 34.16 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 28 and 33 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 48 (Table 5). This optimal management regime will generate the maximum SEV of -$389.88 (Table 13), with a NPW of -$389.46 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,963.83 cubic feet of pulpwood and 10.77 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 34.16 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 31 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 5). This optimal management regime will generate the maximum SEV of $3,319.46 (Table 13), with a NPW of $2,583.41 per acre (Table 9). This financially optimal rotation would produce an estimated 1,984.07 cubic feet of pulpwood and 27.59 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 48.23 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 31 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 5). This optimal management regime will generate the maximum SEV of $347.23 (Table 13), with a NPW of $328.64 per acre (Table 9). This financially optimal rotation would produce an estimated 2,008.87 cubic feet of pulpwood and 26.79 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 47.75 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 28 and 34 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 53 (Table 5). This optimal management regime will generate the maximum SEV of -$191.21 (Table 13), with a NPW of -$187.36 per acre (Table 9). This financially optimal rotation would produce an estimated 2,771.87 cubic feet of pulpwood and 20.25 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 45.50 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 33 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 5). This optimal management regime will generate the maximum SEV of -$330.46 (Table 13), with a NPW of -$327.65 per acre (Table 9). This financially optimal rotation would produce an estimated 2,634.38 cubic feet of pulpwood and 15.11 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 39.26 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 33 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 49 (Table 5). This optimal management regime will generate the maximum SEV of -$372.84 (Table 13), with a NPW of -$371.80 per acre (Table 9). This financially optimal rotation would

produce an estimated 2,634.38 cubic feet of pulpwood and 15.11 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 39.26 net tons of carbon per acre during one rotation (Table 1).

Yellow poplar, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $0/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 25 and 31 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 46 (Table 5). This optimal management regime will generate the maximum SEV of -$387.33 (Table 13), with a NPW of -$386.79 per acre (Table 9). This financially optimal rotation would produce an estimated 3,140.26 cubic feet of pulpwood and 10.38 MBF of sawlogs per acre from the thinning and final harvest (Table 17), and sequester 36.41 net tons of carbon per acre during one rotation (Table 1).

Southern- Yellow poplar - Timber + Carbon Rotations (C = $10/ton)

Yellow poplar, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of $2,796.92 (Table 14), with a NPW of $2,176.93 per acre (Table 10). This means that $2,796.92 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 90 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,176.93 per acre for managing one rotation, or $2,796.92 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,397.73 cubic feet of pulpwood and 21.15 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.21 net tons of carbon per acre during one rotation (Table 2). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Yellow poplar, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 33 and 44 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of $330.03 (Table 14), with a NPW of $313.20 per acre (Table 10). This financially optimal rotation would produce an estimated 2,397.73 cubic feet of pulpwood and 21.15 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 40.21 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 45 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 6). This optimal management regime will generate the maximum SEV of -$157.65 (Table 14), with a NPW of -$155.27 per acre (Table 10). This financially optimal rotation would produce an estimated 2,417.56 cubic feet of pulpwood and 19.07 MBF of sawlogs

per acre from the thinning and final harvest (Table 18), and sequester 38.84 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 30 and 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 6). This optimal management regime will generate the maximum SEV of -$291.66 (Table 14), with a NPW of -$290.11 per acre (Table 10). This financially optimal rotation would produce an estimated 2,509.70 cubic feet of pulpwood and 15.85 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 36.26 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 39 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 6). This optimal management regime will generate the maximum SEV of -$338.46 (Table 14), with a NPW of -$337.72 per acre (Table 10). This financially optimal rotation would produce an estimated 2,568.23 cubic feet of pulpwood and 11.86 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 31.98 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 39 (with 35

percent of basal area removed) and a final harvest is conducted at stand age 50 (Table 6). This optimal management regime will generate the maximum SEV of -$358.08 (Table 14), with a NPW of -$357.79 per acre (Table 10). This financially optimal rotation would produce an estimated 2,725.31 cubic feet of pulpwood and 10.54 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 31.46 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of $2,806.16 (Table 14), with a NPW of $2,183.92 per acre (Table 10). This financially optimal rotation would produce an estimated 2,498.52 cubic feet of pulpwood and 20.93 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 42.84 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 28 and 42 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 56 (Table 6). This optimal management regime will generate the maximum SEV of $447.12 (Table 14), with a NPW of $419.41 per acre (Table 10). This financially optimal rotation would produce an estimated 2,447.87 cubic feet of pulpwood and 21.15 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 43.29 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 6). This optimal management regime will generate the maximum SEV of -$105.12 (Table 14), with a NPW of -$103.29 per acre (Table 10). This financially optimal rotation would produce an estimated 2,557.49 cubic feet of pulpwood and 20.02 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 42.65 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 38 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 6). This optimal management regime will generate the maximum SEV of -$263.89 (Table 14), with a NPW of -$262.20 per acre (Table 10). This financially optimal rotation would produce an estimated 2,855.92 cubic feet of pulpwood and 16.29 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 39.74 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 28 and 33 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 48 (Table 6). This optimal management regime will generate the maximum SEV of -$320.79 (Table

14), with a NPW of -$319.79 per acre (Table 10). This financially optimal rotation would produce an estimated 2,963.83 cubic feet of pulpwood and 11.77 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 34.16 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 28 and 33 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 48 (Table 6). This optimal management regime will generate the maximum SEV of -$345.11 (Table 14), with a NPW of -$344.74 per acre (Table 10). This financially optimal rotation would produce an estimated 2,963.83 cubic feet of pulpwood and 10.77 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 34.16 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 31 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 6). This optimal management regime will generate the maximum SEV of $3,319.46 (Table 14), with a NPW of $2,583.41 per acre (Table 10). This financially optimal rotation would produce an estimated 1,984.07 cubic feet of pulpwood and 27.59 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 48.23 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 31 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 59 (Table 6). This optimal management regime will generate the maximum SEV of $561.04 (Table 14), with a NPW of $531.01 per acre (Table 10). This financially optimal rotation could produce an estimated 2,008.87 cubic feet of pulpwood and 26.79 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 47.75 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 28 and 34 (with 30 percent of basal area removed) and a final harvest in conducted at stand age 53 (Table 6). This optimal management regime will generate the maximum SEV of -$56.53 (Table 14), with a NPW of -$55.39 per acre (Table 10). This financially optimal rotation would produce an estimated 2,771.87 cubic feet of pulpwood and 20.25 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 45.50 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 6). This optimal management regime will generate the maximum SEV of -$236.51 (Table 14), with a NPW of -$234.99 per acre (Table 10). This financially optimal rotation

would produce an estimated 2,821.34 cubic feet of pulpwood and 19.11 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 45.00 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 28 and 35 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 48 (Table 6). This optimal management regime will generate the maximum SEV of -$302.81 (Table 14), with a NPW of -$301.87 per acre (Table 10). This financially optimal rotation would produce an estimated 3,461.69 cubic feet of pulpwood and 13.33 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 41.64 net tons of carbon per acre during one rotation (Table 2).

Yellow poplar, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $10/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 35 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 48 (Table 6). This optimal management regime will generate the maximum SEV of -$332.41 (Table 14), with a NPW of -$332.06 per acre (Table 10). This financially optimal rotation would produce an estimated 3,274.04 cubic feet of pulpwood and 12.95 MBF of sawlogs per acre from the thinning and final harvest (Table 18), and sequester 39.82 net tons of carbon per acre during one rotation (Table 2).

Southern- Yellow poplar - Timber + Carbon Rotations (C = $37/ton)

Yellow poplar, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 42 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $3,642.89 (Table 15), with a NPW of $2,835.11 per acre (Table 11). This means that $3,642.89 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 90 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $2,835.11 per acre for managing one rotation, or $3,642.89 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,247.93 cubic feet of pulpwood and 21.23 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 39.57 net tons of carbon per acre during one rotation (Table 3). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Yellow poplar, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 42 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $752.16 (Table 15), with a NPW of $713.81 per acre (Table 11). This financially optimal rotation would

produce an estimated 2,247.93 cubic feet of pulpwood and 21.23 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 39.57 net tons of carbon per acre during one rotation (Table 3).

Yellow poplar, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 45 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 7). This optimal management regime will generate the maximum SEV of $102.71 (Table 15), with a NPW of $101.16 per acre (Table 11). This financially optimal rotation would produce an estimated 2,417.56 cubic feet of pulpwood and 19.07 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 38.84 net tons of carbon per acre during one rotation (Table 3).

Yellow poplar, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which a thinning is conducted at stand age 37 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 7). This optimal management regime will generate the maximum SEV of -$116.08 (Table 15), with a NPW of -$115.62 per acre (Table 11). This financially optimal rotation would produce an estimated 2,434.31 cubic feet of pulpwood and 17.72 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 24.28 net tons of carbon per acre during one rotation (Table 3).

Yellow poplar, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which a thinning is conducted at stand age 49 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 7). This optimal management regime will generate the maximum SEV of -$209.39 (Table 15), with a NPW of -$209.16 per acre (Table 11). This financially optimal rotation would produce an estimated 2,753.48 cubic feet of pulpwood and 16.25 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 24.56 tons of carbon per acre during the rotation (Table 3).

Yellow poplar, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 50 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 7). This optimal management regime will generate the maximum SEV of -$259.14 (Table 15), with a NPW of -$259.04 per acre (Table 11). This financially optimal rotation would produce an estimated 3,523.02 cubic feet of pulpwood and 13.08 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 24.45 tons of carbon per acre during the rotation (Table 3).

Yellow poplar, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 40 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $4,253.43 (Table 15), with a NPW of $3,310.27 per acre (Table 11). This financially optimal rotation

would produce an estimated 2,350.68 cubic feet of pulpwood and 24.19 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 44.69 net tons of carbon per acre during one rotation (Table 3).

Yellow poplar, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 40 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $956.30 (Table 15), with a NPW of $907.54 per acre (Table 11). This financially optimal rotation would produce an estimated 2,350.68 cubic feet of pulpwood and 24.19 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 44.69 net tons of carbon per acre during one rotation (Table 3).

Yellow poplar, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 29 and 41 (with 30 percent of basal area removed) and a final harvest is conducted at stand age 55 (Table 7). This optimal management regime will generate the maximum SEV of $208.72 (Table 15), with a NPW of $205.08 per acre (Table 11). This financially optimal rotation would produce an estimated 2,557.49 cubic feet of pulpwood and 20.02 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 42.65 net tons of carbon per acre during one rotation (Table 3).

Yellow poplar, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 40 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 53 (Table 7). This optimal management regime will generate the maximum SEV of -$45.96 (Table 15), with a NPW of -$45.69 per acre (Table 11). This financially optimal rotation would produce an estimated 2,992472 cubic feet of pulpwood and 17.23 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 41.84 net tons of carbon per acre during one rotation (Table 3).

Yellow poplar, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 40 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 7). This optimal management regime will generate the maximum SEV of -$160.63 (Table 15), with a NPW of -$160.32 per acre (Table 11). This financially optimal rotation would produce an estimated 3,150.66 cubic feet of pulpwood and 15.77 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 41.10 net tons of carbon per acre during one rotation (Table 3).

Yellow poplar, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 40 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 7). This optimal management regime will generate the maximum SEV of -$221.90 (Table 15), with a NPW of -$221.75 per acre (Table 11). This financially optimal rotation

would produce an estimated 3,287.26 cubic feet of pulpwood and 14.37 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 40.34 net tons of carbon per acre during one rotation (Table 3).

Yellow poplar, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 31 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $4,833.69 (Table 15), with a NPW of $3,761.87 per acre (Table 11). This financially optimal rotation would produce an estimated 1,984.07 cubic feet of pulpwood and 27.59 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 48.23 net tons of carbon per acre during one rotation (Table 3).

Yellow poplar, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 27 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 7). This optimal management regime will generate the maximum SEV of $1,147.67 (Table 15), with a NPW of $1,089.16 per acre (Table 11). This financially optimal rotation would produce an estimated 2,271.95 cubic feet of pulpwood and 27.06 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 50.13 net tons of carbon per acre during one rotation (Table 3).

Yellow poplar, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 27 and 47 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 7). This optimal management regime will generate the maximum SEV of $311.82 (Table 15), with a NPW of $305.98 per acre (Table 11). This financially optimal rotation would produce an estimated 2,788.53 cubic feet of pulpwood and 20.95 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 47.14 net tons of carbon per acre during one rotation (Table 3).

Yellow poplar, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 40 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 7). This optimal management regime will generate the maximum SEV of $22.38 (Table 15), with a NPW of $22.24 per acre (Table 11). This financially optimal rotation would produce an estimated 3,347.11 cubic feet of pulpwood and 17.88 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 46.73 net tons of carbon per acre during one rotation (Table 3).

Yellow poplar, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 40 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 7). This optimal management regime will generate the maximum SEV of -$109.34 (Table 15), with a NPW of -$109.13 per acre (Table 11). This financially optimal rotation

would produce an estimated 3,347.11 cubic feet of pulpwood and 17.88 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 46.73 tons of carbon per acre during one rotation (Table 3).

Yellow poplar, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $37/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 28 and 38 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 48 (Table 7). This optimal management regime will generate the maximum SEV of -$180.82 (Table 15), with a NPW of -$180.63 per acre (Table 11). This financially optimal rotation would produce an estimated 3,958.01 cubic feet of pulpwood and 12.28 MBF of sawlogs per acre from the thinning and final harvest (Table 19), and sequester 43.74 net tons of carbon per acre during one rotation (Table 3).

<u>Southern- Yellow poplar - Timber + Carbon Rotations (C = $50/ton)</u>

Yellow poplar, Site Index 90 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 42 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $4,051.42 (Table 16), with a NPW of $3,153.06 per acre (Table 12). This means that $4,051.42 is the maximum amount that a landowner with a 2.5 percent ARR could pay for one acre of site index 90 bare land and earn 2.5 percent from growing a forest crop. If the landowner already owns the land and follows this economic rotation, he would earn 2.5 percent on every dollar invested plus $3,153.06 per acre for managing one rotation, or $4,051.42 per acre from managing an infinite number of rotations. A negative SEV indicates that the calculated optimal rotation will minimize losses. This financially optimal rotation would produce an estimated 2,247.93 cubic feet of pulpwood and 21.23 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 39.57 net tons of carbon per acre during one rotation (Table 4). Net tons of carbon sequestered are a sum of the carbon removed from the stand during thinnings and final harvests.

Yellow poplar, Site Index 90 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 42 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $956.38 (Table 16), with a NPW of $907.61 per acre (Table 12). This financially optimal rotation would produce an estimated 2,247.93 cubic feet of pulpwood and 21.23 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 39.57 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 90 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 45 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 8). This optimal management regime will generate the maximum SEV of $228.06 (Table 16), with a NPW of $224.62 per acre (Table 12). This financially optimal rotation would produce an estimated 2,417.56 cubic feet of pulpwood and 19.07 MBF of sawlogs per

acre from the thinning and final harvest (Table 20), and sequester 38.84 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 90 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 45 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 8). This optimal management regime will generate the maximum SEV of -$34.27 (Table 16), with a NPW of -$34.13 per acre (Table 12). This financially optimal rotation would produce an estimated 2,417.56 cubic feet of pulpwood and 19.07 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 38.84 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 90 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 37 and 45 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 57 (Table 8). This optimal management regime will generate the maximum SEV of -$153.66 (Table 16), with a NPW of -$153.50 per acre (Table 12). This financially optimal rotation would produce an estimated 2,417.56 cubic feet of pulpwood and 19.07 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 38.84 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 90 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 50 (with 25 percent of

basal area removed) and a final harvest is conducted at stand age 57 (Table 8). This optimal management regime will generate the maximum SEV of -$211.01 (Table 16), with a NPW of -$210.94 per acre (Table 12). This financially optimal rotation would produce an estimated 2,946.15 cubic feet of pulpwood and 15.83 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 25.00 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 100 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 40 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $4,732.27 (Table 16), with a NPW of $3,682.93 per acre (Table 12). This financially optimal rotation would produce an estimated 2,350.68 cubic feet of pulpwood and 24.19 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 44.69 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 100 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which two thinnings are conducted at stand ages 32 and 40 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $1,202.50 (Table 16), with a NPW of $1,141.18 per acre (Table 12). This financially optimal rotation would produce an estimated 2,350.68 cubic feet of pulpwood and 24.19 MBF of sawlogs

per acre from the thinning and final harvest (Table 20), and sequester 44.69 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 100 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which a thinning is conducted at stand age 53 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 58 (Table 8). This optimal management regime will generate the maximum SEV of $362.67 (Table 16), with a NPW of $357.59 per acre (Table 12). This financially optimal rotation would produce an estimated 2,942.47 cubic feet of pulpwood and 17.23 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 46.16 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 100 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 40 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 53 (Table 8). This optimal management regime will generate the maximum SEV of $60.06 (Table 16), with a NPW of $59.71 per acre (Table 12). This financially optimal rotation would produce an estimated 2,992.47 cubic feet of pulpwood and 17.23 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 41.84 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 100 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 40 (with 25

percent of basal area removed) and a final harvest is conducted at stand age 53 (Table 8). This optimal management regime will generate the maximum SEV of -$82.73 (Table 16), with a NPW of -$82.59 per acre (Table 12). This financially optimal rotation would produce an estimated 2,992.47 cubic feet of pulpwood and 17.23 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 41.84 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 100 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which two thinnings are conducted at stand ages 36 and 44 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 51 (Table 8). This optimal management regime will generate the maximum SEV of -$161.91 (Table 16), with a NPW of -$161.80 per acre (Table 12). This financially optimal rotation would produce an estimated 3,322.77 cubic feet of pulpwood and 14.02 MBF of sawlogs per acre from the final harvest (Table 20), and sequester 40.25 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 110 (base age 50), ARR = 2.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 2.5 percent ARR would be the one in which two thinnings are conducted at stand ages 26 and 31 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $5,365.72 (Table 16), with a NPW of $4,175.93 per acre (Table 12). This financially optimal rotation would produce an estimated 1,984.07 cubic feet of pulpwood and 27.59 MBF of sawlogs

per acre from the thinning and final harvest (Table 20), and sequester 48.23 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 110 (base age 50), ARR = 5.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 5.0 percent ARR would be the one in which a thinning is conducted at stand age 27 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 60 (Table 8). This optimal management regime will generate the maximum SEV of $1,439.76 (Table 16), with a NPW of $1,366.35 per acre (Table 12). This financially optimal rotation would produce an estimated 2,271.95 cubic feet of pulpwood and 27.06 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 50.13 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 110 (base age 50), ARR = 7.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 7.5 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 41 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 8). This optimal management regime will generate the maximum SEV of $494.00 (Table 16), with a NPW of $484.74 per acre (Table 12). This financially optimal rotation would produce an estimated 3,013.77 cubic feet of pulpwood and 20.55 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 47.77 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 110 (base age 50), ARR = 10.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 10.0 percent ARR would be the one in which two thinnings are conducted at stand ages 35 and 41 (with 25

percent of basal area removed) and a final harvest is conducted at stand age 54 (Table 8). This optimal management regime will generate the maximum SEV of $149.86 (Table 16), with a NPW of $149.07 per acre (Table 12). This financially optimal rotation would produce an estimated 3,013.77 cubic feet of pulpwood and 20.55 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 47.77 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 110 (base age 50), ARR = 12.5%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 12.5 percent ARR would be the one in which two thinnings are conducted at stand ages 34 and 40 (with 25 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 8). This optimal management regime will generate the maximum SEV of -$14.39 (Table 16), with a NPW of -$14.37 per acre (Table 12). This financially optimal rotation would produce an estimated 3,347.11 cubic feet of pulpwood and 17.88 MBF of sawlogs per acre from the thinning and final harvest (Table 20), and sequester 46.73 net tons of carbon per acre during one rotation (Table 4).

Yellow poplar, Site Index 110 (base age 50), ARR = 15.0%, Carbon Value = $50/ton

The financially optimal thinning and final harvest schedule for 15.0 percent ARR would be the one in which a thinning is conducted at stand age 46 (with 35 percent of basal area removed) and a final harvest is conducted at stand age 52 (Table 8). This optimal management regime will generate the maximum SEV of -$106.84 (Table 16), with a NPW of -$106.77 per acre (Table 12). This financially optimal rotation would produce an estimated 3,846.85 cubic feet of pulpwood and 15.54 MBF of sawlogs per

acre from the thinning and final harvest (Table 20), and sequester 47.39 net tons of carbon per acre during one rotation (Table 4).